

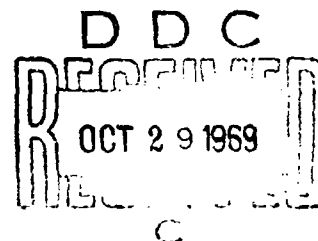
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# U. S. ARMY

## SHORT-TERM MEMORY: AN ANNOTATED BIBLIOGRAPHY

### SUPPLEMENT I

Dennis F. Fisher



September 1969

## HUMAN ENGINEERING LABORATORIES



ABERDEEN RESEARCH & DEVELOPMENT CENTER

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**SHORT-TERM MEMORY: AN ANNOTATED BIBLIOGRAPHY**

**SUPPLEMENT I**

**Dennis F. Fisher**

**September 1969**

APPROVED



**JOHN D. WEISZ**

**Director**

**Human Engineering Laboratories**

**U. S. ARMY HUMAN ENGINEERING LABORATORIES**  
**Aberdeen Proving Ground, Maryland**

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## ABSTRACT

The bibliography is an annotated compilation of 165 references dealing with short-term memory. The bibliography is added as a supplement to *Short-Term Memory: An Annotated Bibliography, August 1968*. The time period covered is predominantly June, 1968 to June, 1969. References included are arranged alphabetically by author. An alphabetical index of pertinent parameters of investigation as well as topics of interest is also provided.

## INTRODUCTION

The present bibliography represents an extension of and supplement to Short-Term Memory: An Annotated Bibliography, August 1968. The bibliography is an alphabetical listing by author of 165 entries with annotations. The annotations are those of the individual authors of the respective papers and are either the abstract or summary statements from the specific reference. This method of presentation was chosen in order to provide the most exact representation of the material reported. Those references included without annotation have been published without abstracts or summary statements or when published, they were considered too long for inclusion.

Following the last entry is an alphabetical index by topic which lists the inclosed references by their number of appearance.

The author wishes that omissions be made known to him and subsequent reports be sent for future compilation.

## A

1. Adams, J. A., Thorsheim, H. I., & McIntyre, J. S. Item length, acoustic similarity, and natural language mediation as variables in short-term memory. Journal of Experimental Psychology, 1969, 80, 39-46.

Four experiments on short-term retention are reported. Retention is known to be an inverse function of number of elements in the item, and Exp. I inquired if this finding is a function of the ease with which natural language mediators (NLMs) are formed. Acoustic similarity and item length were variables in Exp. I. The NLMs functioned as hypothesized, but a confounding with associative strength precluded a theoretical decision about the number-of-elements variable. The effects of acoustic similarity were essentially absent. Experiments II-IV pursued other aspects of acoustic similarity, and the effects of it were small and unsystematic. A need for clarifying the role of the acoustic similarity variable is discussed.

2. Adams, J. A., Thorsheim, H. I. & McIntyre, J. S. Short-term memory and acoustic similarity. Psychonomic Science, 1969, 15, 77-78.

In a STM paradigm, four groups of 96 Ss each had all combinations of low and high acoustic similarity of items and sequential and simultaneous modes of presentation. Acoustic interference occurred as a proactive inhibition effect of prior items, and then only for the sequential mode and an immediate retention test. Acoustic interference was absent at a 30-sec test, showing its short life.

3. Ascoli, M. & Schmidt, A. Proactive interference in short-term motor retention. Journal of Motor Behavior, 1969, 1, 29-36.

Proactive inhibition (PI) in motor short-term memory (STM) was investigated to determine if the PI effects commonly found in verbal STM are also present in motor STM. A simple linear positioning task was used in which a criterion position was presented to the blindfolded S (N=72), with recall of the criterion after either 10 or 120 sec. The variable of greatest interest was the number (either 0, 2, or 4) of similar positions presented prior to the criterion, the previous positions and the criterion being recalled in reverse order following the retention interval. With 4 previous positions, Ss displayed greater absolute error and greater undershooting with algebraic error than with either 0 or 2 previous positions, indicating that PI effects were present in motor STM and that verbal and motor STM may be governed by the same set of laws.

4. Averbach, E. The span of apprehension as a function of exposure duration. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 60-64.

## B

5. Baddeley, A. D. Semantic and acoustic similarity in short-term memory. Nature, London, 1964, 204, 1116-1117.
6. Baddeley, A. D. The influence of acoustic and semantic similarity on long-term memory for word sequences. Quarterly Journal of Experimental Psychology, 1966, 18, 302-309.

It has been shown that short-term memory (STM) for word sequences is grossly impaired when acoustically similar words are used, but is relatively unaffected by semantic similarity. This study tests the hypothesis that long-term memory (LTM) will be similarly affected. In Experiment I subjects attempted to learn one of four lists of 10 words. The lists comprised either acoustically or semantically similar words (A and C) or control words of equal frequency (B and D). Lists were learned for four trials, after which subjects spent 20 min. on a task involving immediate memory for digits. They were then asked to recall the word list. The acoustically similar list was learned relatively slowly, but unlike the other three lists showed no forgetting. Experiment II showed that this latter paradox can be explained by assuming the learning score to depend on both LRM and STM, whereas the subsequent retest depends only on LTM. Experiment III repeats Experiment I but attempts to minimize the effects of STM during learning by interposing a task to prevent rehearsal between the presentation and testing of the word sequences. Unlike STM, LTM proved to be impaired by semantic similarity but not by acoustic similarity. It is concluded that STM and LTM employ different coding systems.

7. Baddeley, A. D. Closure and response bias in short-term memory for form. British Journal of Psychology, 1968, 59, 139-145.

Several attempts to test the Gestalt hypothesis of autonomous change in the memory trace have shown trends which, though mutually consistent, do not fit the Gestalt hypothesis. Experiment I aimed to reproduce these effects. Two figures were used (circles with gaps of  $15^\circ$  or  $60^\circ$ ), one retention interval (15 sec) and two methods of testing: reproduction, in which the subject first copies the figure and then draws it from memory; and recognition, using the method of identical stimuli. In the recognition test, subjects tended to judge an identical  $60^\circ$  gap as 'larger' after 15 sec, implying closure of the gap in the memory trace, but the  $15^\circ$  gap showed no effect. No reliable changes in gap size occurred using the method of reproduction. Experiment II tried to increase the sensitivity of this method by stressing the importance of reproducing the gap accurately. Again results were negative. Experiment III tested the hypothesis that the recognition effect found was due to guessing habits. The initial stimulus was presented as before, but the recognition stimulus was replaced by the momentary illumination of a blank card purporting to be a brief presentation of the recognition figure. Subjects were thus forced to guess. The pattern of responses was almost identical with that found in the previous recognition study. Conclusions are: (1) the consistent trends previously found using the method of identical stimuli are probably due to guessing habits; (2) there is no evidence for autonomous change in the short-term retention of form.

8. Baddeley, A. D. Delay and the digit probe. Psychonomic Science, 1968, 12, 147-148.

The Waugh and Norman probe technique was used to study retention of a seven digit sequence after a delay of 0, 4, 8, or 16 sec filled with letter copying. Results showed: (1) rapid forgetting reaching an asymptote at 15-20 sec (2) forgetting occurred at all serial positions, and (3) forgetting was a function of number of intervening items regardless of whether these were digits to be retained or letters to be copied.

9. Baddeley, A. D. How does acoustic similarity influence short-term memory? Quarterly Journal of Experimental Psychology, 1968, XX, 249-264.

This study attempts to discover why items which are similar in sound are hard to recall in a short-term memory situation. The input, storage, and retrieval stages of the memory system are examined separately. Experiments I, II and III use a modification of the Peterson and Peterson technique to plot short-term forgetting curves for sequences of acoustically similar and control words. If acoustically similar sequences are stored less efficiently, they should be forgotten more rapidly. All three experiments show a parallel rate of forgetting for acoustically similar and control sequences, suggesting that the acoustic similarity effect does not occur during storage. Two input hypotheses are then examined, one involving a simple sensory trace, the other an overloading of a system must both discriminate and memorize at the same time. Both predict that short-term memory for spoken word sequences should deteriorate when the level of background noise is increased. Subjects performed both a listening test and a memory test in which they attempted to recall sequences of five words. Noise impaired performance on the listening test but had no significant effect on retention, thus supporting neither of the input hypotheses. The final experiments studied two retrieval hypotheses. The first of these, Wickelgren's phonemic-associative hypotheses attributes the acoustic similarity effect to inter-item associations. It predicts that, when sequences comprising a mixture of similar and dissimilar items are recalled, errors should follow acoustically similar items. The second hypothesis attributes the overloading of retrieval cues which consequently do not discriminate adequately among available responses. It predicts maximum error rate on, not following, similar items. Two experiments were performed, one involving recall of visually presented letter sequences, the other of auditorily presented word sequences. Both showed a marked tendency for error to coincide with acoustically similar items, as the second hypothesis would predict. It is suggested that the acoustic similarity effect occurs at retrieval and is due to the overloading of retrieval cues.

10. Baddeley, A. D. Prior recall of newly learned items and the recency effect in free recall. Canadian Journal of Psychology, 1968, 22, 157-163.

Battig, Allen, and Jensen (1965) have shown that in free-recall learning, newly learned items tend to be recalled earlier than old items which have already been learned, not later as a simple response-strength theory would predict. Experiment I replicated this result and showed: (1) that a disproportionate number of newly learned items come from the last few items presented; and (2) that the last items presented tend to be among the first recalled, whether "new" or "old." Experiment II showed that when recall is delayed by a task which prevents rehearsal, the effect is reversed; new items s.a recalled slightly later than old items. It is argued that these results reflect the operation of the short-term component in free-recall learning.

11. Bartz, W. H. Dichotic listening and paired-associate recall. Psychological Reports, 1968, 23, 436-438.

Paired-associate recall was investigated in fast-rate dichotic listening. The 72 Ss listened to 24 trials composed of six pairs of words presented simultaneously at 1 pr./½ sec. After each trial S was given a word and instructed to report the one paired simultaneously with it in presentation. A very low level of recall was obtained. The results, taken in combination with slow-rate findings, are in line with a model that hypothesizes sequential processing of simultaneous stimuli.

12. Bartz, W. H. Serial position effects in dichotic listening. Perceptual and Motor Skills, 1968, 27, 1014.

13. Bartz, W. H. Repetition and the memory stores. Journal of Experimental Psychology, 1969, 80, 33-38.

Single-store memory theories predict lesser repetition effects with interpolated activity while two-store theories do not. The Ss recalled 30 lists composed of nine digits; 1 list was presented 10 times, once every third list. Five groups of Ss (n=30) recalled immediately or delayed recall 15 or 30 sec. with and without interpolated activity, shadowing consonants. The results showed that interpolated activity reduced the recall of last-presented items and had no effect on the rate of learning. Superior repetition effects were shown by the delayed recall groups. The results were interpreted as supporting two-store models of memory and indicating that the learning involved a search process.

14. Bartz, W. H., Satz, P., & Fennell, E. Recall strategies in dichotic listening. Proceedings of the American Psychological Association, 1966.



15. Bartz, W. H., Satz, P. & Fennell, E. Grouping strategies in dichotic listening: The effects of instructions, rate and ear asymmetry. Journal of Experimental Psychology, 1967, 74, 132-138.

Grouping strategies and ear asymmetry (EA) were investigated in the Yntema and Trask (1963) dichotic listening (DL) paradigm. Trials consisting of 3 word-digit pairs were recorded at 2 rates, 2 pr. and 1 pr/sec. 8 groups of 20 right-handed Ss differed in terms of rate and instructions for recall: Pairs, Types, Ears, and Free. Results showed that Types and Ears strategies did not differ at either rate, the Ear strategy was most frequent under free recall, and EA effects were significant. Results indicate significant EA effects in DL experiments and should be a factor in models of DL.

16. Bartz, W. H., Satz, P., Fennell, E. & Lally, J. R. Meaningfulness and laterality in dichotic listening. Journal of Experimental Psychology, 1967, 73, 204-210.

Recall strategies and ear asymmetry were investigated where meaningfulness was contingent upon the temporal pairing of individual dichotic pairs of stimuli. Two-syllable words were recorded at the rate of 2/sec. 4 groups of 15 right-handed Ss, differing in terms of Word Type (simple or compound) and Channel (ear presented the first syllable), listened to 10 trials each of 3 pairs of digits, 3 words, and 5 words. The meaningful associations between dichotic pairs had little influence on S's strategy for recall: Ss more frequently adopted an ear-order report. Both word types (saliency effect) and laterality (ear asymmetry) were found to influence S's strategy for recall and number of items recalled.

17. Berkowitz, J. & Reid, S. L. Acoustic factors in short-term memory. Paper Read at Eastern Psychological Association, Philadelphia, Pa. 1969.

The Peterson technique is employed in examining the role of acoustic similarity on short-term retention. Effects of similarity are found to depend upon retention interval and difficulty of interpolated task. Results are interpreted within a decay theory framework and implications for a two-process theory of memory are discussed.

18. Bertelson, P. The time course preparation. Quarterly Journal of Experimental Psychology, 1967, 19, 272-279.

The time course of the adjustments triggered by a warning signal was studied by measuring choice reaction times (RTs) at different predictable foreperiods after such a signal. Before the warning signal, a high time uncertainty situation was created by imposing either a long constant foreperiod of 5 sec or one varying in the range 1.5 to 5 sec. The warning signal was a click. Foreperiods ranging from 0 to 300 millise. were used in different blocks of trials. The stimulus was the onset of one of two lamps calling for the pressing of one of two keys. A control condition, without click, was used also. RTs were found to decrease continuously when the foreperiod was increased from 0 to 100-150 millise. The click delivered simultaneously with the stimulus permitted reactions significantly faster than in the control condition. It is concluded (a) that the latency of preparation can be much shorter than the 2 to 4 sec. reported by Woodrow; (b) that the warning signal can be used as a time cue to start preparatory adjustments without starting a refractory period of the order of magnitude found in experiments with pairs of successive reactions, and thus that such refractory periods are not the inevitable cost of paying attention to a signal. There is also some suggestion that in this situation the click not only triggers

preparatory adjustments, but also causes an immediate facilitation of the reaction to the visual stimulus.

19. Blunt, W. R. STM in retardates as a function of direction and delay of recall. Psychonomic Science, 1969, 14, 69-70.

Direction (forward, backward) and delay (0, 2, 4 sec) of recall was investigated using three groups of 12 retardates each matched on MA and CA. Results indicated significantly more errors occurred in forward learning than in backward learning on Trial 1 only. Analysis of total errors showed delay of recall significant with no differences in frequency or kind of error in forward or backward learning.

20. Borkowski, J. G. & Mann, T. Effects of anxiety and interference on short-term memory. Journal of Experimental Psychology, 1968, 78, 352-354.

Short-term recall for high- (HA) and low-anxious (LA) Ss was compared using a "single-item" technique designed to produce inter-item competition between 6 consecutive CCCCs and to evoke situational anxiety. Results indicated that in the absence of specific, prior interference (PI) there was no difference as a function of anxiety level. As PI developed, the LA group recalled significantly more items than the HA group. However, the superiority of the LA group was not related to the absolute amount of PI. Rehearsal activity (i. e., digit recitation) increased and STM decreased as PI developed. It was concluded that individual differences, such as anxiety, influence the course of short-term memory.

21. Boswell, J. J. & Bilodeau, E. A. Short-term retention of a simple motor task as a function of interpolated activity. Perceptual and Motor Skills, 1964, 18, 227-230.

During Pretraining, S was guided to two targets on a lever positioning device; during training, S made an unguided move to the first target. After a 28-sec retention period, S was tested by asking him to repeat his last move. Two disengagement variables were applied in a factorial combination during the retention interval. One required S to retrieve a pencil from the floor, the other required S to return the lever to zero. It was concluded that the zeroing response did not interfere with retention and that the retrieving response did.

22. Broadbent, D. E. Immediate memory and simultaneous stimuli. The Quarterly Journal of Experimental Psychology, 1957, 9, 1-11.

When two sets of digits are presented simultaneously one to one ear and one to the other, the subject may be asked to write them down from immediate memory beginning with those on an ear chosen by the experimenter. He can do this, but any mistakes are usually amongst those on the ear prescribed for later response. If the subject does not know the order of recall until after stimulation, he either shows low efficiency with the same serial order effect, or else normal efficiency with an altered serial order effect.

When the order of recall is known in advance, efficiency is also reduced by altering the time of presentation of the last items to be recalled; and also by inserting irrelevant items. All these facts are consistent with a particular theory of immediate memory.

23. Broadbent, D. E. A mechanical model for human attention and immediate memory. Psychological Review, 1957, 64, 205-215.

A mechanical model is described, to act as an easy introduction to a formal theory of attention and immediate memory in information theory terms. A number of deductions from the theory which agree with experimental results on human beings are given as descriptions of the behavior of the model.

24. Broadbent, D. E. Techniques in the study of short term memory. Acta Psychologica, 1965, 24, 220-233.
25. Brown, J. Distortions in immediate memory. Quarterly Journal of Psychology, 1956, 8, 134-139.

A series of five pairs of abstract geometrical figures were presented to each subject. Unknown to the subjects, the members of each pair were identical. The second member was presented 10 seconds after the first member and the subject then judged whether a specified feature of the figure had changed in one of two possible directions. One group of 32 Ss were not told which feature of the figure would be critical until presentation of the second member: a further group of 32 Ss were given this information before presentation of the first member. Ss in both groups were significantly consistent with one another in some of their judgements, thus indicating that distortions in remembering had occurred. It is argued that memory distortions of this type (for which previous evidence has been unsatisfactory) are of particular interest since, unlike other memory changes, they are difficult to ascribe to the constructive or inferential character of recognition and recall.

26. Bruce, D. & Murdock Jr., B. B. Acoustic similarity effects on memory for paired associates. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 627-631.

Experiment I tested the short-term retention of paired associates (PAs) with 6-item RA lists and a probe technique. Acoustic similarity between the left-hand members (e. g., LAMP-RAMP) of specific pairs increased proactive inhibition but not retroactive inhibition (RI). Experiment II, which used the same kind of materials, examined RI in memory for PAs following multi-trial practice on two consecutive PA lists. Acoustic similarity had no substantial effect on retention of the first list or learning of the second list. These data suggest that, in short-term retention at least, acoustic similarity effects on the memory for PAs are mostly proactive.

27. Bruning, J. L., Schappe, R. H., & O'Malley, J. J. Active vs. passive interpolated activity in STM. Psychological Reports, 1966, 19, 126.

28. Bryden, M. P. Accuracy and order of report in tachistoscopic recognition. Canadian Journal of Psychology, 1966, 20, 262-272.

The effects of exposure duration and spacing between elements on accuracy of recognition and order of report were examined in two tachistoscopic recognition experiments. In both experiments, Ss viewed horizontal rows of 8 letters. Variations in exposure time between 20 and 120 msec. had little effect on relative accuracy or on order of report. Report sequences tended to begin further to the left at the longer durations than at the shorter ones. Increasing the spacing between the elements improved the relative accuracy in the more central positions, and resulted in a decrease in the tendency to report the material from left to right.

29. Bryden, M. P. Short-term for unbalanced dichotic lists. Psychonomic Science, 1966, 6, 379-380.

Ss heard dichotic lists in which 4 numbers were presented to one ear and, at the same time, 2 numbers were presented to the other ear. Consistent with a decay theory of immediate memory, accuracy on the 2-number series decreased as a function of time since presentation. Variations in recall order indicated that the order of report is determined only after all the material has been heard.

30. Buschke, H. Retention in immediate memory estimated without retrieval. Science, 1963, 140, 56-57.

Report of the missing member of a set depends upon retention of the other members presented. Such a missing scan reveals greater retention than does a digit span and, unlike the digit span, better retention of later than earlier presentations.

31. Buschke, H. Input-output short-term storage. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 900-903.

To determine whether short-term storage and learning may be distinct processes, the input-output missing scan was used to evaluate short-term retention of input, output, and input-output repetitions by patients with and controls without cerebral disease.

Subjects were required to report the four numbers missing from random sequences containing twelve of the numbers 1-16. Each sequence contained four input numbers said by E, four output numbers said by S, and four repetitions said by both E and S. When Ss report as missing numbers did occur in a sequence, the relative frequency of such errors of commission shows the relative retention of input, output, and repetitions.

The major finding is that patients with unselected cerebral disease may show differential impairment in learning repetitions without significant impairment in short-term storage of unpeated input or output. This indicates that short-term storage and a distinct learning process, which may be differentially impaired, both contribute to short-term retention.

32. Buschke, H. & Hinrichs, J. V. Relative vulnerability of item-information in short-term storage for the missing scan. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 1043-1048.

The relative vulnerability of item-information in short-term storage for the missing scan was investigated by comparing error distributions when 12 out of 13 numbers were presented sequentially, either with or without presentation of one additional number. Differential vulnerability by serial position was not found. Differential reporting of numbers with error gradients around correct responses in the ordinal sequence 13-25 suggests that the missing scan may involve storage of the same kind of item-information utilized by natural serial-order recall of numbers.

33. Buschke, H., & Lenon, R. Ordinal gradients in the missing scan. Proceedings, 76th Annual Convention, A.P.A., 1968, 69-70.

## C

34. Cimbalo, R. S. Short-term memory: The effects of task-relevant isolation. Paper Read at Eastern Psychological Association, Philadelphia, Pa. 1969.

The effects of task-relevant isolation were assessed in a memory span task. The results indicated that the enhanced performance on the isolated item was accompanied by decrements in performance for other items in the list. Depending upon the position of isolation either encoding or rehearsal processes are retarded.

35. Cohen, R. L. and Granstrom, K. Interpolated task and mode of recall as variables in STM for visual figures. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 653-658.

Retention of visual figures in STM was studied by varying mode recall and type of material interpolated during the retention interval. Reproduction (modified) was as good as recognition when the retention interval was empty, but was inferior when an interpolated learning task was introduced. The interpolated activity was a PA learning task involving either visual figures, auditory words or both. The data for the reproductive-memory conditions agree well with a limited channel-capacity model, whereas those for the recognition-memory conditions require an RI model. The conclusion is drawn that short-term reproductive memory is mainly verbal whereas short-term recognition memory is mainly nonverbal. This nonverbal type of memory does not exhibit the properties of a sensory visual trace, and is therefore postulated to be a third type of store, over and above the sensory visual and the auditory verbal ones.

36. Conrad, R. Errors of immediate memory. British Journal of Psychology, 1959, 50, 349-359.

Problems of immediate memory have recently come under active consideration both by information theorists and by neurologists. The former have made use of quantitative facts, whilst the latter have based their views on some very general characteristics of forgetting. It is contended that the kind of changes that occur in short-term forgetting cannot be ignored in any account of immediate memory. Accordingly the main types of immediate memory errors are outlined, and some fresh material relating to known errors is introduced. A discussion is developed which considers the value of information theory and current neurological theories, in accounting for these phenomena.

37. Conrad, R. Serial order intrusions in immediate memory. British Journal of Psychology, 1960, 51, 45-48.

The theory that serial order intrusions in immediate memory lead to recall errors was tested experimentally. It was found that increasing the time interval between successive 8-digit messages had no effect on recall performance. Analysis of the response errors showed that with a short interval between messages, serial order intrusions occurred, but they did not occur with long intervals. Thus the amount of error appeared to be independent of the number of intrusions. It is suggested that intrusions occur after recall has failed--there being no causal relationship.

38. Conrad, R. Very brief delay of immediate recall. Quarterly Journal of Experimental Psychology, 1960, 12, 45-47.
39. Craig, J. R., & Bartz, W. H. Repetition effects and the ordered recall of categorized serial lists. Psychonomic Science, 1969, 14, 67-68.

Two-store memory theories predict no repetition effects for last-presented items in serial lists. Thirty lists of 10 numbers were categorized by recording half the list in a male voice and the other in a female voice. The order of the number was repeated every third list in one of the categories. Four groups of Ss (N=10) recalled the categories in serial or reverse order. The results indicated that repetition effects were isolated principally to the first-presented category.

40. Crowder, R. G. On free recall and free-recall scoring in immediate memory. Psychonomic Science, 1969, 14, 255-256.

Subjects were asked for either free or ordered recall of eight-consonant immediate memory stimuli; ordered recall was scored by both free- and ordered-recall criteria. In terms of total errors, free-recall scoring performance was better than ordered-recall scoring; however, instructed free recall was better than ordered recall scored by a free-recall criterion. In all cases, emission of a redundant prefix increased error frequencies. There was evidence that with regard to the shape of the serial position curve, the instructional set was more important than the scoring criterion.

41. Crowder, R. G. Intraserial repetition effects in immediate memory. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 446-451.

Seventy-five Ss recalled series of consonants containing all possible locations of a single repeated element (RE) across 8 serial positions. When the two occurrences of the RE were adjacent or separated by one intervening nonrepeated element (NRE) there was facilitation both of overall recall and of recall for the positions of the RE. When occurrences of the RE were separated by two or more intervening NRE's, there was inhibition of recall at the locations of the RE. The possible roles of input and output processes in intraserial repetition effects were discussed.

42. Crowder, R. G. Repetition effects in immediate memory when there are no repeated elements in the stimuli. Journal of Experimental Psychology, 1968, 78, 605-609.

Two experiments are reported in which Ss recalled series of 8 consonants immediately following auditory presentation. S was required always to include 1 prearranged, redundant consonant in his recall, as a prefix before the series in Exp. I and between the 2nd and 3rd elements in Exp. II. In both studies there was a comparison of inclusive conditions where the redundant letter also occurred as part of the memory series, with exclusive conditions, where the redundant element was never repeated in the memory series. The main finding was that patterns of output repetition in the inclusive conditions affected the form of the serial position curve, simulating, in critical cases, the effects of intraserial repetition (a repeated letter in the series as presented). These results were interpreted as evidence that the effects of distributed intraserial repetition are attributable chiefly to output rather than input processes.

43. Crowder, R. G. The relation between interpolated-task performance and proactive inhibition in short-term retention. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 577-583.

Two experiments were conducted to test the hypothesis that PI decrements in short-term retention are only one aspect of a general tendency for recall of first-presented material to deteriorate over trials and performance on material presented later (the interpolated task) to improve over trials. In the first study, recall of a CCC trigram was shown to decrease over six trials while performance on the interpolated task significantly improved over the same period; however, it was concluded that practice on the interpolated task accounted for this finding rather than some underlying compensatory mechanism. In the second study, Ss recalled series of four words or four letters while executing a perceptual-motor interpolated task. PI was obtained on initial trials and was dissipated by a shift from words to letters (and vice versa) after the first six trials. Interpolated-task performance in this study bore no reliable relationship to level of recall. It was concluded that interpolated-task performance is not an inextricable aspect of PI effects in STM.



## D

44. Dale, H. C. A., & Baddeley, A. D. Remembering a list of two-digit numbers. Quarterly Journal of Experimental Psychology, 1966, 18, 212-219.

The way subjects remember a list of two-digit numbers has been examined in some detail. It is found that intrusions in free recall are not random. They resemble omissions in having the same first digit but not in other ways. This non-randomness of recall errors has been used to construct recognition tests of varying difficulty. Numbers which occurred commonly as intrusions were difficult to distinguish from the correct items when used as distractors in recognition tests. The experiments suggest that the previously observed relationship between recognition efficiency and number of alternatives (Davis, Sutherland and Judd, 1961) can be attributed to the increased probability that such intrusions will be included when the total number of distractors is increased.

45. Dale, H. C. A. & McGlaughlin, A. The recall of repeated items in immediate memory tests. Psychonomic Science, 1968, 12, 145-146.

In general, the recall of a single repeated item was not enhanced on its second presentation. Different repeated items occurring subsequently, however, did show superior recall under certain circumstances. A possible interpretation is that recall is enhanced on repetition only when the Ss expect the item to be presented again.

46. Deese, J. On the prediction of occurrence of particular verbal intrusions in immediate recall. Journal of Experimental Psychology, 1959, 58, 17-22.

Lists consisting of twelve words each were presented to 50 Ss for a test of immediate recall. In the recall of these lists, particular words occurred as intrusions which varied in frequency from 0% for one list to 44% for another. Data gathered on word-association frequencies clearly showed that the probability of a particular word occurring in recall as an intrusion was determined by the average frequency with which that word occurs as an association to words on the list. The correlation between probability of intrusion and mean association value was .873. The regression, over the range examined, was linear, and this suggests the hypothesis that the probability of occurrence of a particular word as an intrusion in recall is proportional to the average association strength of that word to the words on the list.

47. Dornbush, R. L. Input variables in bisensory memory. Perception & Psychophysics, 1968, 4, 41-44.

The effects of a combination of variables previously studied in ordinary and dichotic immediate memory were examined in bisensory memory, wherein the visual and auditory modalities were employed. These variables, combined in a factorial design, were: (1) type of material; (2) rate of presentation of material; (3) order of recall for a modality, either first or second; (4) locus of instructions about order of report; and (5) overall differences in memory for each modality. The variables of instruction, order of report, and nature of materials yielded effects in the bisensory situation similar to those reported for the dichotic and ordinary immediate memory situations. On the other hand, interference effects due to the combination of materials in the two channels were practically nonexistent. Additionally, when the modalities were stimulated simultaneously each displayed curves predictable from data obtained when it was explored independently of the other modality.

48. Dornbush, R. L. Shadowing in bisensory memory. Quarterly Journal of Experimental Psychology, 1968, XX, 225-231.

Shadowing (vocalization-at-presentation) was applied to a bisensory situation where different messages were simultaneously presented to the visual and auditory modalities. Three groups of subjects were employed: Group I shadowed the visual modality; Group II shadowed the auditory modality; Group III was a control, shadowing neither modality. Shadowing in the present experiment facilitated recall of the shadowed modality, particularly the visual modality, which is usually inferior to auditory recall.

It also became apparent that visual recall in an ordinary bisensory situation was minimal if not near an incidental level and that a true bisensory situation with equal division of attention between the two modalities employed does not exist.

49. Dornbush, R. L. Stimulus information and stimulus interference in bisensory short-term memory. Perception & Psychophysics. In press, 1969.

An attempt was made to determine if Ss' strategy of retaining stimulus material changed under conditions of bisensory simultaneous stimulation when one of the two inputs was relevant information as opposed to interference. Thus in Group I Ss were stimulated bisensorily, attended to both inputs (information), but recalled only one input. Ss in Group II were stimulated bisensorily, attended to only one input and recalled only that input (interference). It was found that S's efficiency of recall was decreased in the information condition (Group I) but strategy was not altered. In both Groups, Ss' performed similarly--performance which was in turn similar to that observed in the typical bisensory situation, i. e., where both channels are recalled.

## E

50. Ellis, N. R. Evidence for two storage processes in short-term memory. Journal of Experimental Psychology, 1969, 80, 390-391.

In a probe-type memory task, Ss were required to remember the location of one of nine digits presented in a row with miniature projectors. One group was required to verbalize the numbers aloud as they were presented. A second group remained silent. As in previous studies with this task, a bow-shaped serial position curve was obtained, with the effect of recency higher than that of primacy. Saying the numbers aloud depressed primacy and increased the recency effect as compared to that of the silent group. Presumably, oral verbalization preempted time otherwise used for rehearsal, a main determinant of primacy. On the other hand, recency was facilitated as a result of added sensory cues or recirculation of items through a primary memory. The study was replicated with retardates tested on a seven-position task.

51. Ellis, N. R. & Anders, T. R. Effects of interpolated recall on short-term memory. Journal of Experimental Psychology, 1969, 79, 568-569.

In a probe-type task, STM was significantly reduced by an interpolated recall (first probe) and the effect was significantly larger in the recency portion of the serial position curve. Delay reduced STM of recency but tended to facilitate primacy. An incorrect interpolated recall interfered with retention more than a correct recall. The results indicated that memory for primacy items are more stable than those in recency.

52. Ellis, N. R. & Dugas, J. The serial position effect in short-term memory under E- and S-paced conditions. Psychonomic Science, 1968, 12, 55-56.

In a STM task Ss were presented visually nine CVCs in a row. A probe followed, requiring S to remember the position of one of the CVCs. SPE were found for both E- and S-paced conditions, with S-pacing facilitating primacy performance only. Latencies showed an SPE for 7 of 15 Ss. Long latencies resulted in more accurate performance in primacy, suggesting that Ss use rehearsal strategies.

53. Ellis, N. R. & Hope, R. Memory processes and the serial position curve. Journal of Experimental Psychology, 1968, 77, 613-619.

Four experiments are reported testing the hypothesis of 2 storage processes in recall. In three experiments, Ss were presented a series of nine numbers in a probe-type task at differing rates. As expected, rate (item duration or interitem interval) affected the primacy and middle portions of the curve and not recency. Lower rate presumably facilitated learning and consequently long-term memory (LTM). Another experiment (using 12 letters) varied rate and also interpolated a 0-sec, 10-sec, or 10-sec filled delay between presentation and the probe. Delays attenuated recency (a short-term memory, STM, effect), filled more than unfilled. Unfilled delay elevated primacy and middle portions when rate was fast, but in no other instance. These results were viewed as compatible with the two storage hypothesis. Strong evidence for the role of rehearsal in this task was found.

54. Elmes, D. G. Role of prior recalls and storage load in short-term memory. Journal of Experimental Psychology, 1969, 79, 468-472.

A running PA task was used in Exp. I to separate the effects of the memory requirement on the STM of a given "critical" pair from those effects attributable to the number of pairs and recall tests that precede the critical pair. The memory requirement (storage load) was always zero when the critical pair was presented, while there were 0, 1, 2, 3, 4, or 5 pairs and recall tests preceding the critical pair. Critical item recall was highest when there were no prior pairs, but increases in the number of prior pairs beyond one did not influence critical item recall. In a second experiment, storage load (zero or two) for a critical pair was varied, half of the Ss received a cue to disregard pairs preceding the critical one, and the storage load averaged over all recall points prior to the critical pair was 2.2, 3.2, or 4.2. Although the cue did not influence recall of the critical items, both the storage load and the two highest prior average storage loads were detrimental to critical item recall.

55. Elmes, D. G. Short-term memory as a function of storage load. Journal of Experimental Psychology, 1969, 80, 203-204.

A running PA task was used to examine the role of storage load (SL) in STM while the potential retroactive and proactive inhibition (RI and PI) effects of the items contributing to SL were held constant or minimized. The Ss were presented 16 lists in which the SL at the time of recall of a particular "critical" pair was 1, 2, 3, or 4. Correct recall of the critical items was inversely related to SL. Thus, SL in the absence of differential RI and PI is an important determiner of short-term retention.

56. Elshtain, E. L. and Schaefer, T. Jr. Effects of storage load and word frequency on pupillary responses during short-term memory. Psychonomic Science, 1968, 12, 143-144.

Letter-word memory sequences differing in word frequencies and average storage loads (ASL) were presented aurally to nine Ss. Pupil diameter, measured continuously and electronically with infrared light retroreflected from the retina, increased slightly (3.5%) during loading; markedly during recall (9% to 23% with increasing ASL). Word frequency affected pupil size only at the highest ASL. Recall errors, unaffected by word frequency, increased with increasing ASL. Contrasted with recall errors, pupil dilation indicated processing at lowest ASL (9% increase), some effect of word frequency, and a greater range of effect in relation to ASL.

## F

57. Frost, R. R. & Jahnke, J. C. Proactive effects in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 785-789.

Proactive effects in short-term memory were examined in an attempt to test a "fixed" channel-capacity model of memory. The present study showed no balance between the amount of proactive inhibition (PI) developed for stimulus materials and facilitation for interpolated materials, as a "fixed-capacity" notion appears to specify. To the contrary, PI was found for both stimulus and interpolated materials. Results are consistent, not with a "fixed-capacity" model, but rather with a "limited-capacity" model of memory in which proactive effects appear to develop independently for different classes of materials presented on a single trial and in which PI is equivalent to a shrinkage of channel capacity.

58. Furukawa, J. M., Suydam, M. M., & Miller, S. The effects of grouping instructions in short-term memory. Psychonomic Science, 1969, 15, 81-82.

The effects of two levels of short-term memory (STM) and three levels of instructions were investigated in a serial-learning task. High- and low-STM Ss were assigned simple serial-learning instructions, instructions to learn by quadrupling words. The results from this 2 by 3, extreme-groups design showed that instructions to pair or quadruple words significantly facilitated performance ( $p < .01$ ) and reduced the correlation between STM and learning from .56 ( $p < .05$ ) to .05 ( $p > .05$ ). The difference between high- and low-STM Ss found in an earlier study was eliminated by providing grouping instructions to the Ss.

## G

59. Glanzer, M., & Cunitz, A. R. Two storage mechanisms in free recall. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 351-360.

Two experiments were carried out to test the hypothesis that the bimodal serial position curve in free recall is produced by output from two storage mechanisms--short-term and long-term. Experimental operations were applied that were predicted to have a distinct effect on each of these mechanisms, and the changes in the serial position curve were observed. In the first experiment, presentation rate and repetition of individual words were varied in order to affect long-term storage and thereby affect the beginning sections of the serial position curve. Presentation rate has the predicted effect of differentially raising the beginning section of the serial position curve. It does not affect the end section. Repetition, however, did not have any effect that could not be ascribed to presentation rate. It could not, therefore, be used to demonstrate independently the predicted differential effect. In the second experiment, delay between end of list and recall was varied in order to affect short-term storage and, thereby, the end section of the serial position curve. The predicted effect was clearly demonstrated. The results make it possible to systematize a number of findings in the literature.

60. Goggin, J. Retroactive and proactive inhibition in the short-term retention of paired associates. Journal of Verbal Learning and Verbal Behavioral, 1966, 5, 526-535.

This study investigated whether paradigm of transfer would have the same influence on RI and PI after varying intervals of time in STM as it does in LTM. Two lists, each with 2 pairs of CVC stimuli and word responses, were presented once, followed by number reading. MMFR was given after 6, 22, or 40 sec. Each S was given 3 replications. On Test 1, with positive transfer, List-1 and List-2 recall were equal and Ss did not differ from controls; with negative transfer, PI exceeded RI and Ss recalled significantly less than controls. Recall did not change over time on Test 1. A decrease in recall over tests, a measure of intra-experimental PI, was present and significant.

61. Groniger, L. D. Natural language mediation and covert rehearsal in short-term memory. Psychonomic Science, 1966, 5, 135-136.

The short-term effects of natural language mediators and covert repetitions were studied using high and low meaningfulness CCC<sub>s</sub> with a presentation time of 2 sec, a retention interval of 30 sec, and an interpolated activity of counting backward by threes. Each S was given four items of the same level of meaningfulness. There were 96 Ss in each group. NLM<sub>s</sub> and covert rehearsal were both significant factors in recall. NLM<sub>s</sub> were found to deter proactive inhibition.

## H

62. Haber, R. N. & Hillman, E. R. The effect of repetition on the perception of single letters. Perception & Psychophysics, 1966, 1, 347-350.

Single letters were presented for from one to five flashes, with S required to report what he saw after each flash. The clarity of the letter increased sharply with repetition. Since the letters were no larger than one-third of a degree in size, clarity could not have been increased by S making different fixations from flash to flash and combining them into a total percept. Nor was S guessing, since this could be ruled out by other indicators. Thus, it was included that repetition of the stimulus can have a direct effect on the clarity of S's percept of that stimulus.

63. Haber, R. N. & Nathanson, L. S. Processing of sequentially presented letters. Perception & Psychophysics, 1969, 5, 359-361.

The effect on the number of letters S can report of the duration of each sequentially presented letter was compared with that of processing time, defined as the time from the onset of a letter to the onset of the next letter. Four Ss were each shown 1250 common English words, from four to eight letters long, one letter at a time. Each letter acted as a visual noise field for the preceding letter. The duration of each letter and the interval between letters was varied independently. The S reported the letters he saw after each word was displayed. It was found that the processing time (onset to onset) predicted the number of letters correctly reported, regardless of the partition between on time and off time. A calculation was made of the number of milliseconds of on plus off time that are needed to ensure correct report of each letter. This time was independent on the duration of the processing time, but was positively correlated with the number of letters in the word. The correlation is probably in part artifactual, so that no claim can be made that it takes longer to process a letter of a long as compared to a short word.

64. Harris, G. J. & Laughery, K. R. Visual and auditory intrusions in a short-term memory recognition task. Paper Read at Eastern Psychological Association, Philadelphia, Pa. 1969.

Two studies investigated whether visual as well as auditory information is stored in STM. Ss ability to detect built-in intrusions in recognition tasks suggested that only auditory information is stored. Sensitive analyses, that took into account a priori error probabilities of Ss intrusions, indicated visual information is also utilized.

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65. Henley, N. M., Noyes, H. L., & Deese, J. Semantic structure in short-term memory. Journal of Experimental Psychology, 1968, 77, 587-592.

This paper reports an experiment on semantic structure in short-term memory. A selected portion of the English kinship system provided the semantic structure. Kin terms were drawn from a model having 3 dimensions or features-sex, generation, and lineality-collaterality. Eight terms were used in every possible combination of triads. These triads were presented to Ss who were instructed to recall them on signal. Counting backwards by 3s occupied Ss between presentation and recall. The recall intervals were 4, 8, and 16 sec. Results showed that recall was poorer for triads in which the terms differed by all 3 features rather than only by 2. An analysis of errors showed that more intrusions occurred with 3 features than with 2.

66. Hicks, D. J. Short-and long-term retention of affectively varied modeled behavior. Psychonomic Science, 1968, 11, 369-370.

Children rated the affective meaning of various modeled behaviors and subsequently recalled them after two months and eight months. Short-term retention was significantly greater for positively valenced stimuli, but no difference was found on the long-term measure. Intertrial retention was interpreted as a function of subjective organizational factors.

67. Hinrichs, J. V. Prestimulus and poststimulus cuing of recall order in the memory span. Psychonomic Science, 1968, 12, 261-262.

Permutations of nine-digit sequences were recalled in either forward (F) or backward (B) order with order of recall cued either before the sequences (Prestimulus Cuing) or after the sequences (Poststimulus Cuing). Prestimulus Cuing produced significantly better recall than Poststimulus Cuing and F recall was superior to B recall, with a significant interaction between the two main effects. The shapes of the serial position curves for F and B recall were relatively unchanged by the position of cuing recall order, although the level of performance was lower in the Prestimulus Cuing condition.

68. Hintzman, D. L. Recognition time: Effects of recency, frequency, and the spacing repetitions. Journal of Experimental Psychology, 1969, 79, 192-194.

In a continuous memory task, Ss identified words as "old" or "new" by pressing one of two buttons. Response latency was recorded. Conditions were such that accuracy was about 96%. Each experimental word occurred three times, denoted  $P_1$ ,  $P_2$ , and  $P_3$ . The number of items intervening between  $P_1$  and  $P_2$  was either 1, 2, 4, 8, or 16 items; the number intervening between  $P_2$  and  $P_3$  was always 16 items. Findings were that (a) error latencies were longer than correct response times on all three presentations, (b)  $P_2$  recognition times increased with the length of the  $P_1$ - $P_2$  lag, (c)  $P_3$  times were considerably shorter than those on  $P_2$  and (d)  $P_3$  times decreased with the length of the  $P_1$ - $P_2$  lag, showing a spacing effect.

69. Hofer, R. Intertrial proactive inhibition in short term memory. Psychological Reports, 1965, 17, 755-760.

Ss were given three trials of either a letter-trigram or a word-trigram. Immediately after the trigram a 3-digit number was presented from which S counted backwards by 3s for 8 sec., after which S recalled the trigram. On the fourth trial either the same kind of material as presented before was used or a different kind of material. For letter-trigrams, the recall interval in the fourth trial was either 5, 11, or 17 sec. For word-trigram, only 11 sec. was used as the recall interval. To control for novelty, another group had letter-trigrams for four trials, but in the fourth the trigram was typed in red. Similarity of the material presented on the preceding trials interfered with recall of both letter- and word-trigrams. In addition, the hypothesis that the probability of interference of previous similar materials on the fourth trial would increase with longer recall intervals was supported for letter-trigrams. Novelty did not affect recall.

## J

70. Jahnke, J. C. Presentation rate and the serial-position effect of immediate serial recall. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 608-612.

This study examined the effects of rate of presentation on the serial organization of lists of words near and beyond span-length. The Ss were instructed for the serial (ordered) recall of the lists. Recall was better at slower rates of presentation, but the improvement in recall at the slower rates did not extend to terminal items of a list. Slower rates were found to increase the size of the initial span and to facilitate the ordering of items in recall as requested. Emphasis was placed on both order of presentation and order of recall as determiners of serial-position effects.

71. Jahnke, J. C., & Erlick, D. E. Delayed recognition and the serial organization of short-term memory. Journal of Experimental Psychology, 1968, 641-647.

A probe-stimulus technique was used to measure the recognition of 7-digit strings after delays of 4, 8, or 12 sec. Operating characteristics showed that retention was poorer at longer delays and for items from the middle of the string. Recognition rates ( $d'$ ) appeared to drop most rapidly for terminal items as delay increased, in agreement with analogous results obtained with recall procedures. However, the effects of recency were always greater than those of primacy and the form of the serial-position curve was essentially unchanged by increasing delay, in contrast to analogous results obtained with recall procedures.

72. Jahnke, J. C. & Melton, A. W. Acoustic similarity and the ranschburg phenomenon. Proceedings, 76th Annual Convention, A. P. A., 1968, 65-66.

## K

73. Kahneman, D., Onuska, L. & Wolman, R. E. Effects of grouping on the pupillar response in a short-term memory task. Quarterly Journal of Experimental Psychology, 1968, XX, 309-311.

Subjects heard strings of nine digits for immediate recall at a monotone 1/sec. rate or in groups of three digits separated by pauses. Concurrent measurements of pupil size show a steady dilation in the monotone condition, and brief dilation-constriction waves during the pauses of grouped presentation. The results are consistent with hypotheses concerning rehearsal in the two modes of presentation. Pupillary dilations apparently accompany episodes of covert rehearsal.

74. Kanarick, A. F., & Peterson, R. C. Effects of value on the monitoring of multi-channel displays. Human Factors, 1969, 11, 313-320.

Keeping-track performance was investigated as a function of payoff ratio, display format, stimulus on-time, load, and channel payoff value in a 4 X 2 X 2 X 2 X 2 mixed design. Each of 32 Ss was instructed to keep track of the status of a five- or ten-channel display. On alternate trials, S either was presented with a new piece of information or was interrogated about the present status of a channel. Analysis of the results indicated significant Payoff-Ratio, Format, Stimulus On-Time, Load, and Value effects as well as a significant Load X Value interaction. Results suggested that the greater the load on the operator and the greater the disparity between high- and low-valued information, the more likely selectivity of information is to occur. In addition, the probability of a correct response was investigated as a function of the time the information had to be retained and of the independent variables. Applications of the results to display monitoring contexts are discussed.

75. Karnes, E. W. & Coppock, H. W. Repetition and rehearsal in short term-memory. Proceedings, 76th Annual Convention, A. P. A., 1968, 67-68.
76. Karnes, E. W. Rehearsal and organization in short-term serial retention. Paper Read at Eastern Psychological Association, Philadelphia, Pa. 1969.

The experiment was designed to investigate the nature of rehearsal in short-term serial retention. The results supported the hypothesis that rehearsal in the sense of organizing or chunking of the input information is required for the formation of a "structural" long-term memory trace.

77. Katz, L. Motivation and retrieval in short-term free recall. Journal of Experimental Psychology, 1969, 79, 580-581.

All Ss were tested for free recall of items from sequences that varied randomly in length from four to nine items. At the end of each sequence presentation, S was cued to recall under one of two conditions. Correct reports were rewarded in both conditions. Incorrect reports were punished in one condition (risky recall, R) and were not punished in a second condition (nonrisky recall, NR). The Ss consistently made more reports under NR. However, there was little difference in the number of correct recalls between NR and R. The results suggest that the criterion value of item strength necessary to effect a report under R was near the optimal value; further decreases in criterion had little effect on correct reports. The data are consistent with results of arousal on short-term memory retrieval suggested by Weiner (1966) and Wickens and Simpson (1968).

78. Katz, L. The limited-capacity hypothesis: Effects of sequence length and instructions in free recall. Journal of Verbal Learning and Verbal Behaviors, 1968, 7, 942-944.

Eighteen Ss listened to series of 2-digit items in sequences which varied randomly in length. Nine Ss were given standard free recall instructions (recall in any order, AO). Nine other Ss were required to report the last item in the sequence before reporting the others in any order (recall last first, LF). The results showed no differences between groups in the mean number of items recalled. However, the serial position curves changed as a function of sequence length and instructions. The curves for AO showed relatively strong primacy effect compared to those of LF, which showed relatively strong recency. In addition, memory capacity varied similarly in both groups.

79. Keele, S. W. Repetition effect: A memory-dependent process. Journal of Experimental Psychology, 1969, 80, 243-248.

In choice reaction time (RT) studies it has commonly been found that RT to a repeated stimulus is faster than to nonrepeated stimuli. The first two experiments tested the hypothesis that this repetition effect is a short-term memory phenomenon and that an increased time interval between stimuli or an interpolated filler task between successive stimuli would abolish the effect. This hypothesis was not supported. A third experiment suggested, instead, that the repetition effect was due to stimulus anticipation and the saving in memory search time with correct anticipations.

80. Keppel, G. & Underwood, B. J. Proactive inhibition in short-term retention of single items. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 153-161.

Three experiments were performed to determine the relationship between certain variables influencing proactive inhibition in long-term retention of lists of verbal items and the influence of these variables on short-term retention of single items. More particularly, retention of single items over 18 sec. should, if the laws of long-term retention are applied, decrease with number of previous items to which S has been exposed. In addition, amount of forgetting should be a direct joint function of number of previous items and length of the retention interval.

In Experiment 1 each S was presented consonant syllables singly, with retention being measured after 3, 9, and 18 sec. Forgetting of the first item presented (T-1) was less than for the second (T-2) or third (T-3) item, but forgetting of the latter (T-2 vs. T-3) did not differ. On all three tests forgetting was directly related to length of retention interval, but no interaction was evident between number of previous items and length of retention interval.

In Experiment 2 a higher degree of initial learning of the items was achieved. Forgetting increased directly as a function of number of previous items presented. The predicted interaction was indeterminate since retention was essentially 100% on T-1 for all retention intervals.

Experiment 3 tested retention of six successive items over .3 and 18-sec. intervals. Retention after 3 sec. showed an initial drop and then a rise over the six tests, the rise suggesting a practice effect. Forgetting over 18 sec. increased directly from T-1 to T-6 and there was no indication that a constant amount of proactive interference had been reached. The interaction between length of retention interval and number of potential proactively interfering items was very evident.

The result was interpreted to mean that proactive inhibition in short-term memory of single items follows the same laws as proactive inhibition in long-term memory of lists of items.

81. Kintsch, W. & Buschke, H. Homophones and synonyms in short-term memory. Journal of Experimental Psychology, 1969, 80, 403-407.

Differential effects of acoustic and semantic similarity on primary and secondary memory are shown by analysis of short-term retention for sequences of 16 words containing either homophone pairs, synonym pairs, or unrelated words. After presentation of each sequence, one of the words in the sequence was given as a probe for S to respond with the word that followed the probe in the sequence. Recall of early words in the lists was used to estimate the secondary memory component of short-term retention. Secondary memory was strongly decreased by semantic similarity. Recall of the most recent words in the lists provided a basis for estimation of primary memory. Primary memory was unaffected by semantic similarity, but was decreased significantly.

82. Kirchner, W. K. Age differences in short-term retention of rapidly changing information. Journal of Experimental Psychology, 1958, 55, 352-358.

An experiment was conducted to measure very short-term retention in younger and older Ss by means of a visual display involving a rapidly moving light. The basic time interval between lights for all stages of the experiment was 1.5 sec.

Results indicated that older Ss slumped in performance much sooner than younger Ss, in both relative and absolute terms. Older Ss also tended to make more errors of omission and more random responses, indicating a lack of ability to "keep up." As little or no difference in physical ability to follow the moving light was revealed between young and old, it was suggested that the inability to organize incoming and outgoing information as rapidly as younger Ss caused the older Ss' poorer performance.

83. Klare, G. R., Mabry, J. E., & Gustafson, L. M. The relationship of patterning (underlining) to immediate retention and to acceptability of technical material. Journal of Applied Psychology, 1955, 39, 40-42.

The results of this study indicate that patterning (underlining of selected words) of reading material, even though Ss are given no indication of its rationale, may still result in somewhat greater immediate retention than ordinary material for more able Ss. Less able Ss, on the other hand, may be hindered by such a presentation if they are not told what it means. Further, patterning as used here appears to have little effect on either the speed with which material is read or on its acceptability.

84. Kleinsmith, L. J., Kaplan, S., & Tarte, R. D. The relationship of arousal to short- and long-term verbal recall. Canadian Journal of Psychology, 1963, 17, 393-397.
85. Kothurkar, V. K. Effect of similarity of interpolated materials on short-term recall. Quarterly Journal of Experimental Psychology, 1968, XX, 405-408.

Two experimental studies bear out the assertion that the probability of short-term recall of verbal units is adversely affected by the similarity of interpolated items. The possibility is conceded that some confounding of trace decay and interference factors may occur whenever an interval between an original presentation and its subsequent recall is filled with some intervening activity; yet it may be concluded that the results broadly corroborate and support the interference hypothesis as the major explanation of short-term forgetting, and of the decisive role of similarity.

# L

86. Laughery, K. R. Computer simulation of short-term memory: A component-decay model. Prepublication draft of a chapter to appear in J. T. Spence and G. H. Bower (Eds.), The Psychology of Learning and Motivation: Advances in Research and Theory. Vol. III. New York: Academic Press.
87. Levy, B. A. & Murdock, B. B. Jr. The effects of delayed auditory feedback and intralist similarity in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 887-894.

Three studies are reported in which Ss heard items under delayed or immediate auditory feedback (DAF, IAF). In Exp. 1 associatively similar lists were used in an attempt to limit the use of associative cues, thus forcing the S to rely on acoustic cues. The hypothesized decrement at recall under DAF as compared to IAF was not found. In Experiment II acoustically similar lists of words were used with two presentation rates. Acoustic similarity had an adverse effect on recall in Primary Memory. Presentation rate was an adverse effect on recall in Primary Memory. Presentation rate was an important variable only in Secondary Memory. Experiment III separated visual and acoustic similarity by using letters. Again the acoustic decrement at recall was found. Visual similarity had no effect. A DAF effect was not found in Experiment II or III. The results are discussed in terms of the loss of articulatory cues being the crucial factor determining the acoustic effect. Further, criterion shifts rather than differential decay may account for the effect of acoustic similarity.

88. Lindsay, P. H. & Norman, D. A. Short-term retention during a simultaneous detection task. Perception and Psychophysics, 1969, 5, 201-205.

Subjects were required to perform a short-term memory task and a signal detection task, both individually and simultaneously. Memory performance was impaired only when the signals in the detection task were difficult to detect. The impairment in memory was restricted to items which appeared in the early positions of the list to be remembered. Detection performance was unaffected by the simultaneous task requirement and there was no correlation between performance on the two tasks when both were performed together. The results suggest that the difficulties Ss have when they attempt to perform several tasks at the same time may be due to limitations in the process responsible for storing and retrieving information rather than those involved in the perceptual analysis of the incoming material.



89. Lively, B. L. The isolation effect in short-term memory. Paper Read at Eastern Psychological Association, Philadelphia, Pa. 1969.

An experiment was performed to test the generalization theory of the isolation effect in short-term memory using a probe technique. Isolation was effected at different positions in 10-item lists. The results did not support the generalization theory, but were consistent with an explanation in terms of stimulus recognition.

90. Lloyd, K. E., Johnston, W. A., & Belcher, S. A. Short-term retention as a ratio of average storage load to average load retention. Journal of General Psychology, 1966, 74, 347-353.

An attempt was made to relate short-term recall to a ratio of the average number of items being stored (when a request for recall occurred) to the average number of items requested. When the ratio is unity, all stored items are requested. As the ratio departs from unity, fewer items are requested per recall in relation to the number being stored. Mean recall errors increase as the ratio increases. The shape of the function remains constant despite changes in the ease with which the stored items can be encoded. Within any one ratio, the recall scores are rank ordered directly with both variables in the ratio.

91. Loess, H. & Harris, R. Short-term memory for individual verbal items as a function of method of recall. Journal of Experimental Psychology, 1968, 78, 64-69.

Two experiments were conducted to evaluate different methods of recall in short-term memory. Each experiment contained 96 Ss divided into 4 subgroups. The stimuli were word triads, each containing words from 3 common taxonomic categories. The S saw a triad for 1.5 sec, followed by a series of random digits designed to minimize rehearsal. Retention was measured after 9 sec. In Experiment I, experimental Ss were provided with the appropriate category names at the beginning of a recall interval. Performance was not superior to control Ss who were told simply to recall. In Experiment. II, experimental Ss received category cues after an initial period of free recall. Under these conditions performance was superior to control Ss who had the same total time to recall but no special cues. The results are discussed in terms of (a) opposing facilitative and interfering effects of the recall cues, and (b) different methods of retrieval from short-term and long-term memory.

## M

92. Marcer, D. Subtraction as interpolated activity in short-term retention. Psychonomic Science, 1968, 11, 359.

The maximum rate at which each of eleven Ss could perform a subtraction task was determined. Subtraction was then used as the interpolated activity in a short-term retention experiment. The required subtraction rate was varied to give three experimental conditions--equal to, less than, or greater than the S's maximum. Most forgetting occurred when the required rate equalled the S's maximum rate.

93. Marshall, J. F., Rouse, R. O. Jr. & Tarpy, R. M. Acoustic versus associative models of short-term memory coding. Psychonomic Science, 1969, 14, 54-55.

A 230-item word list was used to study methods of coding. The list consisted of 35 pivot words, one each of their high associates (HA), medium associates (MA), synonyms (S), rhymes (R), plus 20 buffer words. The data indicated that short-term memory coding complied to an associative rather than an acoustical model. The study offers a possible explanation of why different experiments have found acoustical coding predominant in short-term memory.

94. Martin, E., Roberts, K. H. & Collins, A. M. Short-term memory for sentences. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 560-566.

Short-term memory for active and passive sentences at two levels of grammatical complexity was tested at four retention intervals, 0, 10, 20, and 40 sec. Sentence forgetting was analyzed in terms of differential word-class forgetting. It was hypothesized that Ss selectively focus on key word classes, with grammatical structure as the guide to selection, and generate recall sentences around retained elements.

95. Martin, E. & Walter, D. A. Subject uncertainty and word-class effects in short-term memory for sentences. Journal of Experimental Psychology, 1969, 80, 47-51.

The effect of memory-capacity release, determined by whether sentence subjects were low-uncertainty pronouns or high-uncertainty animate nouns, on sentence recall was studied at three retention intervals (0, 10, 30 sec.) in the Peterson STM situation. Verbatim recall of pronoun sentences was markedly superior to that for noun sentences; but although there were striking word-class forgetting effects, the proportion distribution of these effects was little affected either by subject uncertainty or by retention interval. The identify of word-class effects over retention intervals indicates selective processing at the time of input. Error pattern evidence is offered for the hypothesis that recall is a constructive process.

96. Mayzner, M. S. A provisional model of visual information processing with sequential inputs. Technical Report No. 1, August 1967, New York University, Contract Nonr N00014-67-A-0467-0001/NR150-000X/1-9-67, Office of Naval Research.

97. Monty, R. A. Spatial encoding strategies in sequential short-term memory. Journal of Experimental Psychology, 1968, 77, 506-508.

Keeping-track performance was examined as a function of cues designed to control the spatial encoding strategies adopted by Ss. Spatial organization of the material to be remembered significantly affected short-term retention and interacted with the characteristics of the type of stimulus material employed, demonstrating that visual encoding can play an important role in short-term memory.

98. Monty, A. & Karsh, R. Spatial Encoding of Auditory Stimuli in sequential short-term memory. Journal of Experimental Psychology, in press.

The "spatial window" model of encoding previously postulated to account for keeping-track performance with visual stimuli was applied to keeping-track performance with auditory stimuli. The results indicate that spatial encoding can play a role in short-term memory, irrespective of the stimulus modality employed. Further, a complex relation was found between encoding time, rehearsal time, and the nature of the stimulus materials.

99. Monty, R. A., Wiggins, H. F. & Karsh, R. Keeping track of sequential events: Manipulation of the incrementing process. Journal of Experimental Psychology, 1969, 80, 408-411.

The incrementing process in a keeping-track task was manipulated by requiring Ss to either add or subtract new information from their running tallies of past events. As the percentage of subtractions per trial increased, so did the error rate except that 100% subtractions resulted in approximately the same level of error as 100% additions. It was hypothesized that subtraction is inherently more difficult than addition, but subtractions are not perceived as such unless S is confronted with additions on the same trial.

100. Mortenson, F. J., & Loess, H. Effect of very brief interpolated activity on short-term retention. Perceptual & Motor Skills, 1964, 18, 797-803.

Short-term retention of 4-, 6-, and 8-digit messages was tested after 1 and 10 sec. Retention intervals were either unfilled or partially filled following a procedure used by Conrad. Retention of 4-digit messages was essentially perfect under all conditions. Retention after 1 sec. was significantly reduced for 6- and 8-digit messages if "0" was interpolated during the interval. Retention of 8-digit messages was significantly reduced, but retention of 6-digit messages was not reduced, by interpolation of "0" in a 10-sec. interval. Results are interpreted as being compatible with both decay and interference interpretations of forgetting and as indicating that interpolation of a brief activity will significantly reduce retention only when messages approach the limit of memory span.

101. Morton, J. Repeated items and decay in memory. Psychonomic Science, 1968, 10, 219-220.

Subjects were presented with a string of digits, following which they were required to judge which of two test digits occurred more recently in the list. As predicted by a trace-decay model, when the earlier of the test digits was repeated, performance was worse than in the control condition.

102. Morton, J. Selective interference in immediate recall. Psychonomic Science, 1968, 12, 75-76.

An experiment is described which investigates the effects of irrelevant digits interpolated into a list of letters presented for recall. The main result is that when an irrelevant digit follows the final recall item there is a massive serial position effect, with later items in the list being affected more than earlier items. This corresponds to stimulus suffix effects reported by other authors and differs from response prefix effects where no differential serial position effects are noted. It is concluded that the two effects must be ascribed to two different kinds of store, one postrecognition and one prerecognition store.

103. Murdock, B. B. Jr. Decoding as a function of the number of bits per chunk. Journal of Experimental Psychology, 1968, 78, 1-7.

Miller's (1956) coding principle stresses the importance of maximizing the number of bits per chunk. As a test 2 experiments on decoding were conducted; the source message consisted of the 1st 13 letters of the alphabet, and it was encoded with a minimum-redundancy Huffman (1952) code. Experiment I varied the size of the code alphabet (binary, ternary, quaternary, or septenary) while Experiment II varied the S-R compatibility (Normal, Reversed, or Random napping of (septenary) code words and alphabetic letters); in both cases S had to decode the message back into its original form. Mean number of letters decoded per trial increased with size of code alphabet and showed some S-R compatibility effects. Miller's coding principle was clearly supported, and evidence was adduced to suggest that it need not contravene Hick's (1952) Law.

104. Murdock, B. B. Jr. Response latencies in short-term memory. Quarterly Journal of Experimental Psychology, 1968, XX, 79-82.

This paper deals with the problem of the interpretation of response latencies in short-term memory. A paired-associate study using a probe technique was conducted with the main experimental variation the length of the recall interval (1, 2, or 4 sec). While shortening the interval had a statistically significant effect on recall probability the interaction between recall interval and probe position was negligible. While traditionally response latency is considered a measure of associative strength, such an interpretation seems inappropriate here. As an alternative, latencies may reflect more criterion values than sensitivity as these measures are interpreted in signal-detection theory.

105. Murdock, B. B. Jr. & Ogilvie, J. C. Binomial variability in short-term memory. Psychological Bulletin, 1968, 70, 256-260.

Experiments in short-term memory usually collect binary data (e. g., an item is either correctly recalled or not). If the probability of recall is constant for Ss and/or items under a given condition, the proportion based on  $n$  observations can be transformed to angles by the arcsin transformation and will have variance  $1/n$ . Violations of the assumptions are discussed and different strategies for pooling are assessed by conventional analysis of variance. Illustrative experiments with distractor and probe techniques, paired-associates and serial presentation, and single-trial free recall are briefly presented. The correspondence between observed and expected results seems good; apparently considerable latitude is possible in pooling Ss or items in data analyses of experiments in short-term memory.

106. Murray, D. J. Vocalization-at-presentation and immediate recall, with varying presentation rates. Quarterly Journal of Experimental Psychology, 1965, 17, 47-56.

An experiment is reported in which the subject read visually presented lists with four different degrees of vocalization; immediately after reading each list he was required to reproduce it either aloud or in writing. Each list consisted of eight consonants and presentation rates were varied between 1 and 4 letters per sec. For any given series of lists, the subject was asked either to read the letters silently, or to mouth them silently, or to whisper them, or to say them aloud while reading.

At the fastest presentation-rate immediate recall improved monotonically with the degree of vocalization during reading of the lists; at slower rates this generalization held less well, especially for the lower degrees of vocalization. Vocalization was most helpful at the highest presentation-rate.

The overall amount correctly recalled was better for more slowly presented lists and for written as opposed to spoken recall. Analysis of the errors suggested that acoustic confusions were affected by the conditions of presentation; and that serial order intrusions were independent of presentation- or recall-conditions. An apparent variation of transpositions with voicing-and-recall-method failed to reach statistical significance. Theoretical implications of the experiment are discussed, including reference to Broadbent's theory of short-term memory (1958).

107. Murray, D. J. Articulation and acoustic confusability in short-term memory. Journal of Experimental Psychology, 1968, 78, 679-684.

Lists of letters varying in length and in acoustic confusability were presented for immediate probed recall. Presentation was either visual (with nonarticulation, silent articulation, or articulation aloud) or auditory (with nonarticulation or silent articulation). It was found that recent visual items which were articulated gave acoustic confusability effects intermediate between the heavy effects obtained when retrieval was ostensibly from an auditory afterecho and the negligible effects obtained when retrieval was ostensibly based on visual memory. These results suggest that articulation enhances the discriminability particularly of recent items in STM, and also that visual or auditory STM can be investigated independently of STM for speech-coded information.

108. Murray, D. J. Repeated recall in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1969, 7, 358-365.

Lists of eight letters were either voiced or silently read at presentation, the presentation rate being either 1, 2, or 3 letters/sec. Immediate spoken recall was then given, three times in succession. It was found that accuracy of recall decreased over successive recalls, with errors in the early recalls tending to be perpetuated over later recalls; that the rate of recall was faster for rapidly presented lists than for slowly presented lists, but also increased over successive recalls; and that the loudness of recall decreased over successive recalls. The relationships between successive recalling, postlist rehearsal, and learning are discussed with reference to these results.

# N

109. Newell, M. The effects of acoustic disruption on short-term memory. Psychonomic Science, 1968, 12, 61.

Forty-six, 10 and 11 year old children in grade five remembered significantly fewer letters from sets of five consonants after hearing an acoustic disturbance during a five sec retention interval than under normally quiet conditions. Their short term memory was effected significantly more by a scream than by a tone.

110. Nodine, C. F. & Korn, J. H. Role of affect in short-term memory for paired associates. Journal of Experimental Psychology, 1968, 78, 494-501.

Short-term memory (STM) for "minimal" paired associates (PA) was investigated by presenting Ss 2 successive picture-trigram (Experiment I) or picture-letter (Experiment II) PA units. Affective content of 1 stimulus term was pleasant (P) and the other was unpleasant (U). After either a 3-, 9-, or 15-sec retention interval, during which Ss engaged in number tracking, 1 of the 2 PA units was tested for recall. Recall of U units was inferior to P units for both response classes. However, with letters, recall of P was higher than U at immediate recall (3 sec) but affect did not differentially influence recall at 9 and 15 sec. With trigrams, differential recall extended from 3 to 15 sec with U inferior to P at all retention intervals. These findings suggest that the differential influence of affect on STM varies directly with task difficulty which can be specified in the PA task by response availability.

111. Norman, D. A. Toward a theory of memory and attention. Psychological Review, 1968, 75, 522-536.

A theoretical structure is described to account for a variety of phenomena encountered in the study of perception, attention, and memory. A storage system is proposed which has 2 different nodes of activation: a temporary excitation, called short-term or primary storage, and a permanent excitation, called long-term or secondary storage. The storage is assumed to be organized so that access to stored information can be made directly from a sensory code. Thus, the initial interpretation of sensory events can be performed automatically, allowing attention to be directed to events on the basis of their meaning and momentary psychological pertinence. A retrieval process is described to handle the problem of deciding when an item that is recovered from storage is that which was sought. The output from storage is accepted as valid only if it can lead back naturally to the original query of memory. If it cannot, the retrieval process continues, using the initial query together with each intermediate output to guide the direction of search.

112. Norman, D. A. & Waugh, N. C. Stimulus and response interference in recognition-memory experiments. Journal of Experimental Psychology, 1968, 78, 551-559.

An analytical technique for determining the effects of stimulus- and test-list interference on the strengths of recent memory traces is described and demonstrated. The probability that an item will be recognized as one that recently occurred depends on the amount of interference attributable to the items that follow it in a study list, and the items and responses that precede it in a test list. The exact relationship between the 2 types of interference seems to depend on various details of the experimental procedure used.



# P

113. Paivio, A. & Csapo, K. Concrete image and verbal memory codes. Journal of Experimental Psychology, 1969, 80, 279-285.

It was hypothesized that concrete (visual) imagery functions primarily as a parallel processing system, whereas the verbal symbolic system is specialized for sequential processing; and that performance in nonsequential memory tasks would accordingly vary directly with the availability of both memory codes, but the verbal code alone would be crucial in sequential memory. The availability of imagery was manipulated by the use of abstract words, concrete words, and easily labeled pictures as stimuli. The availability of the verbal code, in the case of pictures, was varied by presenting the stimuli at rates presumably above and below implicit labeling threshold. Immediate memory span and serial learning constituted the sequential tasks; free recall and recognition memory, the nonsequential tasks. Consistent with predictions (a) memory for pictures was significantly inferior to words only in the sequential memory tasks, and then only at the fast rate; (b) both pictures and concrete words exceeded the abstract words in serial learning at the slow rate; and (c) pictures were significantly superior to abstract words at the slow rate in both nonsequential tasks, with concrete words intermediate in each case.

114. Peterson, L. R., Peterson, M. J., & Miller, A. Short-term retention and meaningfulness. Canadian Journal of Psychology, 1961, 15, 143-147.

Recall of individual trigrams after 6 sec. was found to vary with meaningfulness as measured by association value. At recall sequential dependencies between letters within the items were found to vary with association value. Frequency of occurrence in recall of initial letters did not vary with association values: it was concluded that letter-sequence habits may underlie differences in response recall related to meaningfulness. Mean latencies of correct responses at a 6-sec recall interval were not different between sets of trigrams from the two extremes of Archer's scale, even though gross differences in recall were found. It was therefore considered unlikely that mediating responses had any significant role in response recall. Increases in latency and decreases in frequency of correct responses were found to be gradual over recall intervals of 1, 2, 3, and 6 sec for low association value trigrams.

115. Pillsbury, W. B. & Sylvester A. Retroactive and proactive inhibition in immediate memory. Journal of Experimental Psychology, 1940, 27, 532-545.

116. Pollack, I. Interference, rehearsal, and short-term retention of digits. Canadian Journal of Psychology, 1963, 17, 380-392.

117. Posner, M. I. Characteristics of visual and kinesthetic memory codes. Journal of Experimental Psychology, 1967, 75, 101-107.

This study compares retention of kinesthetic information from blind positioning movements with information from similar visually guided movements. Reproduction of the visually guided movement shows little or no forgetting when the interval (20 sec) is unfilled and forgetting is greatly increased by an interpolated attention-demanding task. The blind movements show clear forgetting even with an unfilled interval and are not much affected by the interpolated task. These results confirm previous findings that storage in these tasks involves more than verbal labels and suggest that visual and kinesthetic STM codes have different central processing requirements.

118. Poulton, E. C. & Brown, C. H. Memory after reading aloud and reading silently. British Journal of Psychology, 1967, 58, 219-222.

Twenty-four housewives read passages aloud and silently in balanced order, and then answered questions on them. Time allowed for silent reading was matched to time taken to read aloud. Memory for the first 30 per cent of the passage was reliably ( $P < 0.02$ ) less after reading aloud, as if the monitoring of speech put an extra load upon the central mechanisms, thus interfering with memorization. For most of the remainder of the passage memory was equally good after reading aloud and silently. Presumably the vocal output had been programmed to run with the minimum of attention. The last 10 percent of the passage was remembered reliably better after reading aloud ( $P < 0.01$ ), as if vocalization had given it extra emphasis.

119. Pylyshyn, Z. W. Information available from two consecutive exposures of visual displays. Canadian Journal of Psychology, 1965, 19, 133-144.

Two experiments are described which used a technique of exposing a stimulus twice in succession with a variable interexposure delay. This technique was seen as allowing more time for post-exposure processing of information for a given length of exposure duration. The result of Exp. I confirmed the expectation that more information is available from the double than the single exposure. In addition, the amount of information available increased with increasing interexposure delays up to 5 sec.

A second experiment was directed at replicating the above result with a different display and with the longest delay increased to 10.8 sec. In addition, control conditions were introduced to determine the effect of a second flash on the report of information from a brief display--independent of the information contained in that flash. The results confirmed the effect found in Experiment I except at the longest inter-exposure delay.

The purpose of Experiment IIb was to determine how information is acquired from the two exposures individually for two of the delays (0.4 sec and 10.8 sec). Some of the trials in this experiment were designed so that, unknown to the subject, one digit of the second display differed from the corresponding digit in the first display. The results showed that for the short delay almost all of the correctly reported digits originated in the second display. For the long delay about half originated from the first display. Furthermore, in a long-delay case, those originating from the first display were reported more accurately if they were towards the left end of the array whereas the reverse was true for those originating from the second display. This was taken to suggest that the more time was available to process information from a display the less susceptible would it be to interference or substitution.

## R

120. Rabbitt, P. M. Learning to ignore irrelevant information. The American Journal of Psychology, 1967, 80, 1-13.

Two experiments used a training-transfer paradigm to investigate learning of irrelevant symbols in visual search tasks. Groups of Ss were practiced at locating members of particular sets of relevant letters embedded among restricted vocabularies of irrelevant letters. Search-time reduced with practice, but increased when Ss were transferred to displays incorporating a new irrelevant vocabulary. This increase in search-time on transfer provided an index of the extent to which improvement related to learning of cues was specific to discriminations between particular relevant and irrelevant sets.

The results of Experiment I suggest that the number of cues used to discriminate relevant from irrelevant letters increases with the number of relevant letters for which the S is required to search. Experiment II suggested that search time is less affected by the relative sizes of the relevant and irrelevant vocabularies than by the particular physical characteristics of symbols in the relevant and irrelevant sets. These results are discussed in the context of recent experiments investigating the time taken to discriminate between classes of signals.

121. Rabbitt, P. M. A. Channel-capacity, intelligibility and immediate memory. Quarterly Journal of Experimental Psychology, 1968, XX, 241-248.

When subjects try to remember lists of digits played to them through pulse-modulated white noise the number of errors they make is greater than would be expected if digit-recognition errors and immediate memory errors were independent (Exp. I).

A second experiment compared recall of digits in early list positions, when digits in subsequent list positions were presented through noise, and in clear. Digits in early positions were less well remembered when digits in later list positions had to be discriminated through noise.

In a third experiment prose passages were played to subjects who subsequently answered questions about their factual content. Judged by this technique recall of the first half of a prose passage is less accurate if the second half must be heard through noise than if the entire passage is heard through a good fidelity system. These results together are interpreted as demonstrations that increased difficulty of recognition of speech through noise may interfere with other activities, (conveniently termed "rehearsal") which may be necessary to efficiently retain data in memory.

122. Ross, B. M. Sequential visual memory and the limited magic of the number seven. Journal of Experimental Psychology, 1969, 80, 339-347.

Two experiments report the performance of 180 congenitally deaf and 180 hearing Ss who were required to retain sequentially presented series, nine items long, composed of either two, three, or four different symbols. Results support the claim that memory span for naive Ss consists of only four or five items, not the seven or eight obtained with the highly practiced material and special scoring method of digit span. This shorter span was found for all randomly ordered series, and only the inclusion of certain sequential patterns in some series produced a significant increase in retained items beyond four or five. As hearing Ss were clearly superior to deaf Ss in only a single three-symbol condition, immediate memory models that required an auditory-vocal system for the storage of visual sequential information are contradicted.

123. Russ, D. & Loess, H. Taxonomic cues as aids to recall in short-term memory. Journal of Experimental Psychology, 1969, 80, 394-396.

Short-term memory for word triads was tested in 120 Ss. The words belonged to common taxonomic categories, e. g., animals, countries, vegetables. Each triad contained words from three different categories, e. g., bear-canada-spinach. A brief presentation of a triad was followed by 10 sec of digit recitation, and then Ss saw either (a) "Recall," (b) the names of categories, or (c) "Recall," and 6 sec later, the names of the categories. Over a 12-sec recall period, retention was significantly greater for c than for a or b. The results replicated previous findings by Loess and Harris (1965). The conclusion was that the superior recall of c was due to a real facilitation provided by the delayed taxonomic cues rather than an artifact of guessing strategies.

## S

124. Sanders, A. F. & Schroots, J. J. F. Cognitive categories and memory span: I. shifting between categories. Quarterly Journal of Experimental Psychology, 1968, XX, 370-372.

Broadbent and Gregory's hypothesis that shifting selection between cognitive classes is at least inefficient is tested by varying the number of transitions from consonants to digits and back in a mixed list memory span situation. No orderly decrease is found as a function of the number of transitions, which renders the attention hypothesis unlikely. An alternative position in terms of interference theory could explain the data qualitatively. Tests of further predictions of this theory need first an estimate of the degree of difference between cognitive classes.

125. Sanders, A. F. & Schroots, J. J. F. Cognitive categories and memory span: II the effect of temporal vs. categorical recall. Quarterly Journal of Experimental Psychology, 1968, XX, 373-379.

Subjects were presented with mixed list of elements chosen from at least two formally distinct cognitive categories and were instructed to recall either temporally (i. e. in the actual order of arrival), or categorically (i. e. first all elements of one category followed by those of the other). Temporal recall is found to be superior when the categories are even and uneven digits; categorical recall is better when consonants and tones or consonants and spatial positions are mixed. Approximately equal performance is found with consonants and digits. It is suggested that efficiency of recall strategy depends on the relative strength of pre-existing associative bonds between elements from different cognitive categories. When these connections are weaker the probability increases that class membership rather than succession in time determines the assimilation of the list. It is found that with consonants and digits it does not matter whether instruction is given before or after presentation. This suggests that both recall modes can be activated at the same time. The implication of this result for work on dichotic listening is discussed.

126. Salvin, H. B. On Conrad's prefix and grouping in short-term memory. Quarterly Journal of Experimental Psychology, 1968, XX, 123-128.

Requiring a subject to say a redundant prefix before he recalls a sequence of digits impairs his ability to recall that sequence. Evidence reported below suggests that the prefix functions exactly as an extra nonredundant digit--that the subject performs exactly as if the prefix had to be learned anew on each trial.

127. Scheirer, J. C. & Voss, J. F. Reminiscence in short-term memory. Journal of Experimental Psychology, 1969, 80, 262-270.

Reminiscence in the short-term memory of single associations was studied in a series of six experiments. The data indicated that duration of interpair interval was the primary factor producing reminiscence, thus suggesting that reminiscence is attributable to interference from previously presented pairs. Another finding was that essentially no forgetting occurred after 8 sec., regardless of stimulus presentation duration or verbal material. The results were considered in relation to other studies which demonstrated reminiscence, and the findings also were related to three hypotheses involving the nature of the interference found in the present experiments. They hypotheses were (a) classical interference, which attributes interference to the amount and similarity of material; (b) a two-stage processing hypothesis, which attributes interference to the first or processing stage; and (c) an acquisition hypothesis, which attributes interference to the influence of prior on acquisition, not retention, of new pairs.

128. Sherman, M. F. & Turvey, M. T. Modality differences in short-term serial memory as a function of presentation rate. Journal of Experimental Psychology, 1969, 80, 335-338.

Nine-digit sequences were presented in the visual mode and auditory mode for immediate recall under comparable conditions. Three interitem intervals of .6 sec., 1.2 sec., and 2.0 sec. were used in each mode, with item duration held constant. The number of correct items recalled in the correct order, prior to an error or omission, was significantly greater for the presentation in the visual mode at the longer interitem intervals of 1.2 and 2.0 sec. This superiority of the visual mode over the auditory mode at the slower rates of presentation was interpreted as evidence for the presence of a more flexible rehearsal strategy in the visual mode. This strategy allows S to rehearse earlier items in an acoustic code while storing recent items in the visual preperceptual system.

129. Sitterley, T. E. Short-term retention of sequentially presented digits as a function of interdigit interval, digit duration, and series length. Journal of Experimental Psychology, 1968, 78, 174-178.

The purpose of this experiment was to delineate more fully the effects of digit duration, interdigit interval, and series length upon retention. 10 Ss were presented series of 4, 6, 8, 10, and 14 digits in ascending (4 to 14) and descending (14 to 4) order, at durations and intervals of 100, 200, 500, 1000 msec. Percentage of digits recalled increased as a function of increased interval or duration. The data indicated that Ss perceived and encoded new information while they simultaneously organized and rehearsed previously presented information. In addition, short-term memory has a limited capacity, influenced by presentation rate, and exceeded whenever stimuli were received at a rate higher than about 2/sec.

130. Sloboda, W. The disturbance effort of white noise on human short-term memory during learning. Psychonomic Science, 1969, 14, 82-83.

The Ss had to learn a seven-digit number presented either with or without a 5-sec 72-dB burst of white noise. No significant difference was found in recall between white-noise and no-white-noise conditions with either a 2- or 12-sec retention interval (RI). GSR measures did not differentiate the white-noise and no-white-noise conditions, nor were differences found in recall performance between trials with large drops in resistance and those showing minimal changes. A rho of -.86 was found for the 12-sec RI between background skin resistance (BSR) and performance, with those Ss having higher BSR. No comparable correlation was found for the 2-sec RI.

131. Smith, M. C. Repetition effect and short-term memory. Journal of Experimental Psychology, 1968, 77, 435-439.

Two experiments are reported which attempted to determine the basis of the "repetition effect," i. e., the observed shorter reaction time (RT) for repeated events than for nonrepeated events. The 1st experiment was designed to determine whether the effect was due primarily to peripheral response facilitation, or primarily to more central coding effects. By employing a condensing task in which the same response was made to 2 different stimuli, it was concluded that the effect was not due to peripheral response facilitation, but appeared to be more central in origin. The 2nd experiment tested the hypothesis that the repetition effect resulted from short-term activation of the S-R memory trace. Some support was found for this prediction. It was found that the repetition effect declined with increasing intertrial interval (ITI) over a range in which decline in short-term memory (STM) is typically reported, and that RT for both repeated and nonrepeated events increased with increased ITI, indicating that increased fading of the memory trace occurred in both conditions.

132. Smith, W. R. Retention as a function of natural language mediation and of time. Psychonomic Science, 1968, 14, 288-289.

Subjects learned 20 CVC pairs and reported the method used in learning (rote or natural language mediator, NLM). After 1, 3, or 9 days, recall was tested and method of learning was reported. Recall was virtually unchanged over 9 days for those pairs for which the NLM reported at recall was the same as at acquisition. Retention was low for pairs learned by rote or with a NLM that was forgotten at recall, and decreased as the retention interval increased.

133. Sperling, B. Phonemic model of short-term auditory memory. Proceedings, 76th Annual Convention, A. P. A., 1968, 63-64.

134. Spring, C. Decay and interference theories of short-term forgetting. Psychonomic Science, 1968, 12, 373-374.

Decay and interference theories of short-term forgetting were evaluated. Length of recall interval and amount of retroactive interference were systematically varied. In order to eliminate rehearsal, incidental recall was measured. Forgetting was not affected by varying length of recall interval, but it increased as amount of interference was increased. Results are interpreted as support for an interference theory of short-term forgetting.

135. Standing, L., Haber, R. N., Cataldo, M. & Sales, B. D. Two types of short-term visual storage. Perception and Psychophysics, 1969, 5, 193-196.

Seven-letter words were flashed repetitively at various durations above and below the recognition threshold for single flashes. One form of a short-term storage effect was studied by measuring the interstimulus interval between flashes at which S reported that the stimulus became phenomenally discontinuous in time. Storage times reached a maximum of about 30 msec in this task. A second form of storage effect was measured by decreasing the interstimulus interval until S could correctly recognize a repeated stimulus whose duration was below the single-flash recognition threshold; this effect extended to 900 msec in some cases. Each of these effects was reliably obtained for both rare and frequent words. Both forms of storage were increased by providing a dark rather than a lighted adapting field between presentations of the test stimulus. Implications for information processing of brief displays are discussed.

136. Stanners, R. F. & Meunier, G. F. Pronunciability and rehearsal time in short-term memory with controlled acquisition. Paper Presented at Southwestern Psychological Association, April 1969.

Ss attempted to memorize visually presented sequences of 3 trigrams which were either easy (E-Pr) or difficult (D-Pr) to pronounce. After being equated for performance at a 0-sec retention interval, the Ss received trials composed of presentation of the trigrams, a rehearsal period of 0, 5, or 10 sec., and a retention period of 0, 5, or 10 sec. The S was uninstructed regarding the rehearsal period and was engaged in backward counting during the retention period. The average exposure time required to equate performance at a 0-sec. retention interval was about 10 times as long for the D-Pr material as for the E-Pr material. At the 0-sec level of rehearsal retention functions for the E-Pr and D-Pr material began at the same point and then diverged, with performance for the E-Pr material the lower. At the 5- and 10-sec levels of rehearsal the retention functions for the E-Pr material rose above that of the D-Pr material and the divergence disappeared. For both E-Pr and D-Pr material rehearsal had the effect of flattening the retention functions.



137. Stelmach, G. E. Short-term motor retention as a function of response-similarity. Journal of Motor Behavior, 1969, 1, 37-44.

The present study examined short-term retention in a simple lever-positioning task. The basic variables were the degree of similarity of prior responses about a target ( $\pm 5$  deg.,  $\pm 15$  deg., and  $\pm 25$  deg.) and the length of retention interval (5, 15, and 50 sec). It was found that the absolute errors at recall were inversely related to the similarity of the prior responses about the target position. In all conditions, forgetting was found to be an increasing function of the retention interval. The loss of retention over short periods of time was interpreted as being consistent with verbal short-term memory studies. The results on the similarity of responses were in direct opposition to the findings usually observed in verbal tasks. Comparisons with verbal responses are difficult to make since the nature of retention measurement is different in verbal tasks.

138. Sternberg, S. High-speed scanning in human memory. Science, 1966, 153, 652-654.

When subjects judge whether a test symbol is contained in a short memorized sequence of symbols, their mean reaction-time increases linearly with the length of the sequence. The linearity and slope of the function imply the existence of an internal serial-comparison process whose average rate is between 25 and 30 symbols per second.

## T

139. Taub, H. A. & Greiff, S. Effects of age on organization and recall of two sets of stimuli. Psychonomic Science, 1967, 7, 53-54.

Short-term recall of sequences of 8 letters was measured for 12 young and 12 aged Ss in a control condition with a single stimulus set and three experimental conditions which differed in arrangement of two sets of color-coded stimuli. The results indicated that there were no differences in performance for the stimuli to be recalled first, while both age and conditions were significant effects for the stimulus set to be recalled second.

140. Taub, H. A. & Monty, R. A. Order of recall in short-term memory. Psychonomic Science, 1968, 12, 259-260.

Short-term recall of letter sequences, color-coded into two halves, was measured as a function of color presented first, alphabet half presented first, order of report, and blocks of trials. Analysis of the first half of Ss' reports suggested that reports which reversed the colored halves were superior to an ordered report of the colors except in trial block one when the letters presented first in a sequence were from the first half of the alphabet. Trends from the second half of a report were in the direction of more accurate recall with reversed as compared to ordered reports.

141. Turvey, M. T. & Wittlinger, R. P. Attenuation of proactive interference in short-term memory as a function of cueing to forget. Journal of Experimental Psychology, 1969, 80, 195-198.

Two experiments were conducted to examine the effect of cueing Ss either "not to remember" or "not to recall" encoded trigrams upon the buildup of proactive interference in short-term memory. Experiment I showed that cueing S on certain trials not to remember the items he was encoding produced a significant reduction in proactive interference. In Experiment II, S was cued on certain trials not to recall the item he had previously encoded and stored. This manipulation did not significantly reduce proactive interference although the direction of the difference between the experimental and control conditions was the same as in Experiment I. The results suggest that the act of responding to, or encoding, an item does not of itself determine the interference potential of that item in a short-term memory test series.

## V

142. Von Wright, J. M. Selection in visual immediate memory. Quarterly Journal of Experimental Psychology, 1968, XX, 62-68.

The sampling (partial report) technique of Sperling (1960) was used to study the efficiency of selection of letters from visual immediate memory (sensory storage). Selection by location, chromatic colour, achromatic colour, and size was fairly efficient whereas selection by orientation was difficult. Some parallels between selection in visual immediate memory and selective listening are briefly discussed.

## W

143. Warren, R. E. Short term memory for simultaneous digits. Unpublished Thesis, University of Oregon, 1968.

144. Waugh, N. C. The effect of intralist repetition on free recall. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 95-99.

The Ss were presented with lists of unrelated English words which they were to recall in any order. Within each list, four different words were repeated two, three, four, and five times, respectively. The proportion of repeated words that were recalled consistently exceeded the proportion predicted by the all-or-none hypothesis, which states that items are memorized either completely or not at all.

145. Waugh, N. C. Immediate memory as a function of repetition. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 107-112.

146. Waugh, N. C. & Norman, D. A. The measure of interference in primary memory. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 617-626.

The Ss attempted to remember a minimally rehearsed serial association after attending to a sequence in which items were either ordered at random or repeated according to certain rules. The results indicate that, although a new and unpredictable item may displace an earlier one from primary memory, a recently presented and redundant one does not.

147. Weiner, B. & Reed, H. Effects of the instructional sets to remember and to forget on short-term retention: Studies of rehearsal control and retrieval inhibition (repression). Journal of Experimental Psychology, 1969, 79, 226-232.

Five short-term memory experiments are reported which examined whether the instructional set to forget affects trace formation or trace retrieval. The experimental paradigms included a manipulation of covert rehearsal efforts, variation in the temporal point in the memory sequence at which a remember or forget instructional cue is introduced, a "latent memory" design in which Ss perceived identical stimuli under shifting instructional sets, and a procedure in which identical stimuli were repeatedly perceived under constant instructional sets. The results strongly suggest that the motivational set to forget hinders trace utilization, rather than original learning. In addition, the retrieval deficit caused by the instruction was not necessarily mediated by conscious cognitive processes. The relevance of this work to the clinical conception of repression was emphasized.

148. Wickelgren, W. A. Size of rehearsal group and short-term memory. Journal of Experimental Psychology, 1964, 68, 413-419.

One hundred thirty-two undergraduates were given sequences of 6 to 10 digits presented at 1 digit per second with ordered recall instructions. Ss were instructed to rehearse silently in nonoverlapping groups of 1, 2, 3, 4, or 5 digits. Rehearsing in 3's was optimal, being superior to 2's in ordered recall ( $p < .01$ ), item recall ( $p < .01$ ), and position recall ( $p < .05$ ), insignificantly superior to 4's in ordered and position recall, but not item recall, and significantly superior to 2's in ordered recall ( $p < .01$ ), item recall ( $p < .01$ ), and position recall ( $p < .05$ ), digits tended to the same position in different groups for groups rehearsing by 2's and 3's ( $p < .01$ ) and to other positions in the same group for groups rehearsing by 4's and 5's ( $p < .05$ ). The results support the hypothesis that only 3 serial-position concepts (beginning, middle, and end) are important cues in short-term memory.

149. Wickelgren, W. A. Acoustic similarity and retroactive interference in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 53-61.

Short-term memory for a list of four letters, followed by a list of eight letters that the Ss copied as they were presented, followed by immediate recall of the original four-letter list, was shown to be a function of the acoustic similarity of the intervening list to the original list. An interfering list whose letters have similar pronunciation to the letters in the original list produces greater RI than an interfering list whose letters have a very different pronunciation from the letters in the original list. An interfering list composed of items identical to items in the original list, but in a different order, tends to produce less RI in the recall of items and more RI in the recall of the correct position of these items than an interfering list composed of similar items. These findings for STM are completely consistent with analogous studies of RI as a function of similarity in LTM.

150. Wickelgren, W. A. Short-term memory for repeated and non-repeated items. Quarterly Journal of Experimental Psychology, 1965, 17, 14-25.

Digit sequences containing repeated items are retained differently in short-term memory from sequences containing no repeated items. The repeated items are remembered better or worse than items in the corresponding positions of "all-different" sequences depending on the number of times the item is repeated, the number of items repeated, the number of items intervening between the occurrences of a repeated item, and the position of the repeated items in relation to the beginning and end of the sequence. In every type of repetition studied, except one, memory for the non-repeated items in sequences with repeated items is better than for the corresponding items of all-different sequences. This is true in some cases despite significant specific interference between the (non-repeated) items following the separated occurrences of repeated items. The negative effects in memory for repeated items and the positive effects in memory for non-repeated items are greater when the items are presented at the rate of five per sec. than at one per sec., contrary to the hypothesis that differential rehearsal is responsible for these effects. The results are interpreted as supporting an "associative," as opposed to a "non-associative," theory of short-term memory, as this distinction is defined in the paper.

151. Wickelgren, W. A. Similarity and intrusions in short-term memory for consonant-vowel digrams. Quarterly Journal of Experimental Psychology, 1965, 17, 241-246.

Subjects listened to lists of six consonant-vowel digrams presented at the rate of 0.8 sec./digram and copied them as they were being presented. Immediately after finishing copying the list, they attempted ordered recall of the six digrams. The digrams in each list were chosen from a population of eight digrams consisting of all digrams that can be constructed from the consonants "f" and "n," the vowels "a" and "o," and the two orders "CV" and "VC." Intrusions tended to be similar to the presented digram, and the frequency of an intrusion was a monotonic increasing function of degree of similarity to the presented digram. The ordering of intrusion frequency for each similarity type was from greatest to least: ++ (same consonant, different vowel, same order), ++-, -++, -+, +- -, --+, ---. The findings indicate that forgetting is not all-or-none, that digrams are coded in terms of phonemes, and that initial vs. terminal position is a distinctive feature of consonants, but not vowels, in short-term memory.

152. Wickelgren, W. A. Associative strength theory of recognition memory for pitch. Journal of Mathematical Psychology, 1969, 6, 13-61.

Recognition memory for pitch was studied by means of a delayed comparison task, with the standard (S) tone and the comparison (C) tone separated by a variable delay interval (0-180 sec). Evidence is presented for the existence of an unsigned familiarity or similarity dimension in addition to the signed pitch-difference dimension. Subjects relied on familiarity exclusively in the same-different judgment and used both dimensions in the higher-same-lower judgment. There appear to be two memory traces, short-term and intermediate-term, which are decaying exponentially to zero at very different rates. The decay of the short-term trace appears to be an essentially passive, temporal decay process, rather than an interference process, since the frequency-similarity and intensity of the interference tone have no effect on the rate of decay. The decay of the memory trace appears to have the same form and rate regardless of the initial level of acquisition and regardless of the frequency difference between the S and C tones.

153. Wickelgren, W. A. Auditory or articulatory coding in verbal short-term memory. Psychological Review, 1969, 76, 232-235.

Attempts to determine whether the verbal short-term memory (STM) trace is in an auditory system or an articulatory system by comparison of the confusion matrices for auditory recognition and STM are shown to be based on assumptions that are very likely invalid. Attempts to decide this question by means of the effects of noise on STM are also shown to be inconclusive. Finally, the possibility must not be ignored that the trace is in an abstract verbal system that is neither purely auditory nor purely articulatory.

154. Wickens, D. D. & Clark, S. Osgood dimensions as an encoding class in short-term memory. Journal of Experimental Psychology, 1968, 78, 580-584.

Three experiments were conducted to determine whether or not words are encoded for short-term memory (STM) storage by the connotative meaning of the extremes of the 3 dimensions of the Osgood semantic differential. Fifty experimentals and fifty controls served in each experiment. After reciting 3 words (a triad) twice and a backwards counting task, Ss attempted recall. On the 5th trial experimental groups were presented a triad from the opposite end of the same differential scale; control groups received a triad from their usual end of the dimension. In all instances the experimental groups excelled the control groups to a significant degree on the shift trial, or, in other words, a release of proactive inhibition (PI) occurred. The results imply that the words at each end of the semantic differential scale are homogeneously encoded in STM and represent a psychological class differing from words at the other end of the scale.

155. Wickens, D. D., Clark, S. E., Hill, R. A., & Wittlinger, R. P. Investigation of grammatical class as an encoding category in short-term memory. Journal of Experimental Psychology, 1968, 78, 599-604.

In the Peterson-type STM experiment, proactive inhibition (PI) builds up rapidly but will be released if a shift to a new class of materials is introduced. This report describes 5 experiments investigating the possibility that a release will occur when a shift is made from adjectives to verbs and vice versa. The experiment used triads of words and obtained retention measured after 15 sec. In the first 4 experiments, release of inhibition was obtained when the shift occurred. However, it seemed possible to account for these effects by either phonetic or semantic factors. The final experiment sampled a broad class of words, avoiding semantic and phonetic uniqueness within a grammatical class. In this experiment, no inhibition release was found and it was concluded that grammatical class of verbs or adjectives is not used to encode words in STM.

156. Wickens, D. D. & Eckler, G. R. Semantic as opposed to acoustic encoding in STM. Psychonomic Science, 1968, 12, 63.

The Ss were given triads of consonants or words in the Peterson and Peterson situation. After PI had been built up for the CCCs the Experimental group was given a word trigram such as Pea, Kay, Bee and the Control group received the homophonic triad P, K, B. A significant improvement in performance was shown for the Experimental group and none for the Control. It is concluded that semantic factors override any acoustic factors which might operate in this type of STM situation.

157. Wolf, T. M., & Jahnke, J. C. Effects of intraserial repetition on short-term recognition and recall. Journal of Experimental Psychology, 1968, 77, 572-580.

The retention of 7-digit strings in which the digit in Serial Position (SP) 2 was repeated in either SP 4, 5, 6, or 7 was measured by recognition (Exp. I) and recall (Exp II). Performance on repeated digits was facilitated relative to corresponding control digits in all conditions of Experiment I. Performance on repeated digits was inhibited ( the Ranschburg phenomenon) in all experimental conditions of Experiment II but that one in which the repeated items were most closely adjacent. An attempt was made to explain the apparently contradictory findings of the present experiments in terms of differences between the processes of recognition and recall.



## ADDENDUM

158. Conrad, R. Order error in immediate recall of sequences. Journal of Verbal Learning and Verbal Behavior, 1965, 4, 161-169.

The only attempts to account for order errors in serial recall, have been informational analyses leading to models involving separate storage for item and order information. The present study begins by showing that there is a high degree of association between order and item errors. Items which acoustically confuse with each other are likely to transpose in recall.

This result suggests that apparent order error could arise from two or more independent item errors substituting for each other. Taking into account the demonstrated association between acoustic similarity of items and liability to confuse in recall, the chance that two independent item errors will form a transposition is much increased beyond the pure chance level. This chance is even further increased because (a) acoustic confusions in recall reciprocate, and (b) when sequences are such that repetition of items does not occur, when Ss have made one mistake, they are more willing to make a wrong report on a later item than to be led into a repetition.

It is concluded that memory models do not necessarily need a mechanism which could transpose the order of items in storage. A simpler model is suggested in which items are fixed in the input order, encoded only according to properties of individual items. There is in addition a response availability store from which item substitutions are drawn. The size of this store is independent of vocabulary size, is relatively small, and consists primarily of recent responses only. Thus even when sequence items are drawn from a very large vocabulary, this modified mutual substitution model would still be adequate to account for differences between the order in which items enter and leave a memory store.

159. Fell, J. C., & Laughery, K. R. Short-term memory: Mode of presentation for alphanumeric information. Human Factors, in press. In Laughery, K. R., Fell, J. C. and Pinkus, A. L. Short-term memory: A collection of three papers. State University of New York at Buffalo, April, 1969.

Performance in a memory-span task using 8-letter sequences was explored as a function of presentation rate (.5, .75, 1.0, 2.0 and 3.0 sec./item) and presentation mode (visual, auditory, simultaneous visual and auditory, and mixed visual and auditory). Results indicate that performance in the mixed mode was inferior to the other three modes, but the other modes did not differ from each other. As presentation rate decreased performance improved. These results are consistent with current theories of memory and indicate that the mode in which alphanumeric information is displayed is unimportant provided the modes are not mixed.

160. Laughery, K. R., & Fell, J. C. Subject preferences and the nature of information stored in short-term memory. Journal of Experimental Psychology, in press. In Laughery, K. R., Fell, J. C. and Pinkus, A. L. Short-term memory: A collection of three papers. State University of New York at Buffalo, April 1969.

A two-part experiment was carried out to explore performance on a memory-span task as a function of the presentation mode that Ss prefer. The first part of the experiment used a memory-span procedure involving 8-letter sequences where the presentation mode (visual or auditory) was randomly mixed. In the second task Ss were exposed to auditory and visual 5-letter sequences simultaneously and could record either the auditory or visual sequence - establishing a preference. The compatibility between mode preference in the second task and relative performance on visual and auditory items in the first task showed that Ss perform better on auditory items regardless of their mode preference. This result is interpreted as support for the notion that STM is basically an auditory storage system.

161. Laughery, K. R., & Pinkus, A. L. Explorations with a simulation model of short-term memory. Proceedings of the International Joint Conference on Artificial Intelligence, Washington, D. C., May 1969. In Laughery, K. R., Fell, J. C. and Pinkus, A. L. Short-term memory: A collection of three papers. State University of New York at Buffalo, April 1969.

A simulation model of human short-term memory has been formulated. The model postulates a number of basic information processes which are executed in a serial fashion and each has an associated time parameter. The model also postulates that information is lost from memory as a result of decay. The nature of this decay is exponential and its rate is a model parameter. Several studies were simulated in which the processing-time and decay-rate parameters were manipulated in order to determine the model's sensitivity to these parameters. Also, the model's performance was examined as a function of whether or not visual information is stored in STM and whether order information is retained perfectly or lost as a result of decay. The results of these simulated studies were compared to experimental data in order to determine at which parameter values and under which conditions of visual and order information storage the model performs most appropriately.

162. Sperling, G. Visual information storage. In Proceedings of the Sixteenth International Congress of Psychology, Bonn, 1960. Amsterdam: North-Holland Publishing Company, 1962, 558-559.
163. Wickelgren, W. A. Effects of different terminal sounds on short-term memory for initial consonant sounds. Nature, 1964, 203, 1199-1200.

164. Yntema, D. B., & Trask, F. P. Recall as a search process. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 65-74.

We have suggested that it can as a practical matter be useful to regard recall as a search through memory and consider how a data-processor might be programmed to find the desired response. A demonstration experiment in which recall was examined by what might be called the "method of the missing item" was discussed to point out that a process of searching and testing may reasonably be assumed to intervene between memory and overt response.

Two examples were given to illustrate the suggestion that this point of view can be helpful. The first was an experiment on immediate recall of six items presented two at a time, one to one ear and one to the other, at the rate of one item per ear every half-second. Each pair of items that were presented together consisted of a word and a digit, and the side on which the word was presented varied haphazardly from pair to pair. Recall was more successful when S was instructed to report the items of one type and then the items of the other type than when he was instructed to report the items heard on one side and then those heard on the other. The conclusion was that Broadbent's discovery about the preferred order of recall should not be ascribed to an inability to shift attention rapidly from ear to ear; the task is better described as a problem of data-retrieval.

The second example was an experiment on an unconventional question that arises when recall is viewed as a search by a data-processor: may items in memory be assumed to carry time-tags that the processor can examine to determine which occurred more recently? The S received a long series of words, alternately seeing new words and judging which of two he had seen more recently. An equal-discriminability scale of recency in a series of concrete nouns was constructed and was compared with a similar scale for a series of abstract words.

165. Yntema, B., Wozencraft, T., & Klem, L. Immediate serial recall of digits presented at very high rates. Paper presented at the meeting of the Psychonomic Society, October 8-10, 1964, Niagara Falls, Ontario.

Lists of 3 to 9 highly intelligible digits were sounded by a computer at rates of 2 to 10 digits a second. Performance improves with decrease in rate. Apparently S has time to organize the list at slow rates: recall of lists of 6 digits is less affected by rate when the list is organized for him by presenting the first 3 digits to one ear and the last 3 to the other.

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